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Department of Economics

Price transmission in the Swedish wheat market and implications on a structural shock in demand

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Abstract

This thesis is evaluating price transmission patterns in the Swedish market for feeding and milling wheat. This is done to identify if a market shock - that occurred in one region 2008 - had had a significant impact on other regional prices. After reviewing Literature and Methods, a Vector Error Correction approach is used to estimate elasticities and speed of adjustment, to see how prices react. Using differential analysis, a specific structural shock in demand is evaluated to see if the relative prices with a reference price changed. The shock has been the expansion of an ethanol-plant in the region Norrköping that increased its demand by 300% to 597.000 tons of milling wheat. The analysis is going to show, that under certain assumptions a price increase of 80 – 110 SEK/ton for the different qualities can be determined.

Abbreviations

ADF = Augmented Dickey Fuller Test
AR = Autoregressive Process
ARMA = Autoregressive Moving Average Process
CE = Cointegration Equation
ES = Excess Supply
EQ = Equation
IRF = Impulse Response Function
LOP = Law of One Price
Norr = Norrköping/Mälardalen-Area
NSP = Net Social Payoff
Oest = Östgötaland-Area
USDA = United States Department of Agriculture
VAR = Vector Autorregression
VECM = Vector Error Correction Model

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Chapter 1) Introduction

Under recent years, prices of internationally traded commodities moved extensively over time. Oil, grains, livestock and other products are more and more exposed to international influences due to an increasing globalization, cheap transportation and decreasing trading barriers. 2010, a drought in Russia led to the biggest increase in commodity prices since the first oil crisis in 1973 (Kolesnikova 2010). Followed up by extreme weather phenomena and dryness in America and Russia, shrinking wheat supply caused prices of staple foods to rise extensively in 2012, implying tremendous difficulties in food security, especially for the poor (USDA 2012, Devitt 2012).

However, it is not only food-security that is threatened by volatile prices. Even though controversial debates like Food-for-Fuel¹ directed the awareness of people on ethical issues in the use of agricultural commodities, sectors using agricultural commodities as inputs prospered in the last decade. Especially in the USA and Europe, thoughts about how to ensure fuel-security arose after the oil-crisis in the 70's and led to extensive spending on renewable and everywhere producible energy. Since then, the USA and Brazil became the market leading producers of Bio-ethanol². In Europe, considerations on how to protect the environment and ensure a stable fuel supply caused the production of ethanol to increase under recent years (Renewable Fuel Association 2014).

In order to profit from the rising demand, the Swedish company Lantmännen decided to expand an existing ethanol producing plant in Norrköping in 2008. Despite an uncertain and difficult market environment, Lantmännen became the biggest national producer of bio-ethanol with customers in whole Northern Europe, causing changes on the markets for grain in Sweden (Lantmännen Annual Report 2012).

If the supply- and demand-conditions change, prices are most often affected to a high extent. Therefore, the question rises which implication that has on regional and over-regional prices that are often linked through trade. This thesis is aimed to answer the question on how regional prices in Sweden react and what implications the expansion of the plant had had in the markets.

¹ Using agricultural commodities for the production of fuel

² Ethanol attained by fermentation and distillation of agricultural commodities, such as grains, wood and sugar cane

1.1) Background

Even though the role of bio-ethanol is overall very promising, the Swedish market is facing difficult market conditions. Despite an increasing use of alternative fuel and the reductions of subsidies in the US, the prices for ethanol just fell strongly in the last months of 2013. A strong Swedish crown is easing the import of foreign-origin ethanol, causing a difficult market environment with unknown future for the whole branch in Sweden (Lantmännen Year-End Report 2013).

In Norrköping, the original plant has been producing since 2001. The input-demand of the plant increased with inaugurating of a second production line in November 2008 to up to 600.000 tons of grain per year. Besides, the yearly output of ethanol quadrupled to 225.000 cubic meters, producing 175.000 tons of protein feed for animals, which are sold as by-product. Before the expansion, the grain-input was approximately 150.000 tons of grain (Lantmännen Annual Report 2009/2012).

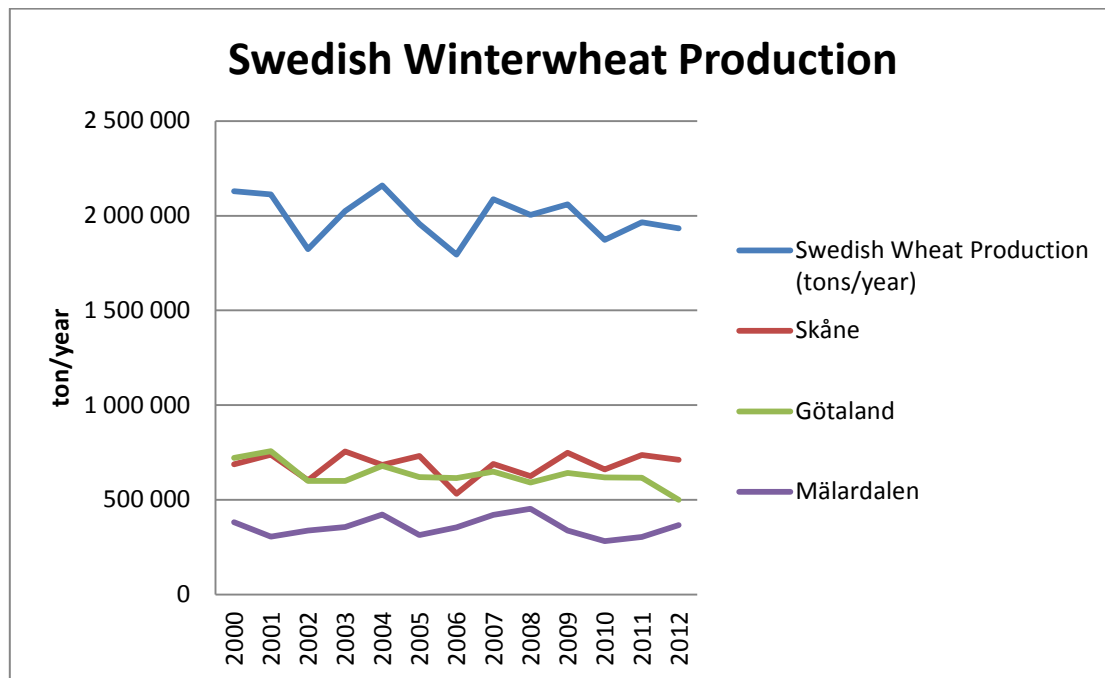
In this thesis the effect of the plant on different regions is evaluated. Sweden consists of 21 regions that are divided into several municipalities. In 2012, the national crop of winter-wheat has been 1,933 million tons. Over the last ten years a stable produced quantity can be observed. The biggest production-areas are located in south (Skåne) and middle Sweden (Göteborg and Mälardalen).

Figure 1.1) The 21 Swedish regions,
Source: Worldatlas, <http://www.worldatlas.com/>

The following figure gives an overview about the total crop of winter wheat in the different regions. The three highlighted ones – Skåne, Göteborg and Mälardalen - contributed 82% of the total crop to the national production 2012.



Figure 1.2) Swedish winter wheat crop 2000 – 2012:



Source: Swedish agricultural agency (Jordbruksverket),
<http://statistik.sjv.se/Dialog/Saveshow.asp>

1.2) Problem formulation

The increase in demand for inputs due to the expansion of the plant changed the market conditions for wheat growing farmers in the area around. The input-quantity rose from 150.000 tons in 2007 to 597.000 tons in 2012, an increase of 300%. That corresponds to 23% of the total national production in Sweden, why it is assumed that the plant had had an impact on the national prices. Because Lantmännen is a cooperation owned by 32.000 Swedish farmers, information has been requested on the impact in the adjacent regions.

Figure 1.3) Yearly demand for grain of the plant

Year	Input
2007	154 000 ton
2008	167 000 ton
2009	428 000 ton
2010	513 000 ton
2011	504 000 ton
2012	597 000 ton

The most important question is: How have prices been influenced in the three areas Mälardalen, Götaland and Skåne? To answer that issue, the sub-questions are how prices are linked, how changes transmit to other markets and to what extent they reacted to the structural change.

Economic theory suggests that due to arbitrage and the Law of One Price³, markets that are connected or integrated are adapting to changing supply and demand conditions, depending on the degree of market-integration. The higher it is the faster and more perfect is the reaction in these linked markets.

1.3) Aim of the study

This study's approach evaluates:

- 1) To which extends prices show co-movement over time, that is, measuring the degree of market integration with established and advanced econometric modeling
- 2) How different prices react to shocks in other markets and how this is influencing their long run behavior
- 3) Testing for structural breaks to determine if and to what extend changes in the markets occurred and if they are related to the plants' expansion in 2008
- 4) If prices behave according to economic theory
- 5) Quantify the impact of the plant in order to give an answer for Lantmännen's owners.

To do this, following measures and concepts are modeled and evaluated:

- 1) The estimation of a quantitative relationship between prices in order to understand how markets are economically related
- 2) Testing for co-movement of prices and the degree of market integration to clarify why and how prices do or do not move together
- 3) Causality tests to evaluate which prices cause others to change and which take on a leader- or follower-role in interregional price determination
- 4) Analysis of Impulse response functions in order to examine the effects of shocks on prices in different regions
- 5) Structural break tests to determine if structural changes related to the plant can be observed in the data.
- 6) Differential analysis to quantify the exact impact of the plant on prices

³ Law of One Price (LOP): All goods have the same value despite different origins (see Chapter 2.1)

1.4) Significance of the study

The study identifies possible shocks in prices and tries to find a statistically significant effect that can be observed in order to quantify the impact of the plant's expansion. This contributes to Lantmännen's approach of transparency for the owners to answer their questions on the influence of the plant and especially how Swedish grain farmers have been affected.

There are no recent studies about price-transmission and shock-evaluation in the Swedish grain market. However, historical issues have been conducted. For example, Bengtsson and Jörberg (2011) evaluated the degree of market integration in the wheat market in the 18th and 19th century and found Sweden to be one single free-trade-area. Another study has been conducted that is evaluating the influence of financial institutions on the volatility of grain prices in 1700-1900 with a short discussion of transmission effects in Sweden (Berg 2007). Besides the requests of Lantmännen's owners for solving the question, this study gives information how Swedish prices behave in a modern context.

1.5) Delimitation

Two qualities of grain are evaluated, that are milling- and feeding-wheat. It is determined by factors such as protein-content, shape and damages. Because of its favorable properties, milling-wheat is preferred for the production of ethanol and therefore this market has presumably been directly affected by the plant. However, due to transmission- and substitution- effects, feeding-wheat may also show price-effects and hence both qualities are evaluated.

To find a significance impact in Sweden, the analysis is extended by an international/reference price that is important for the regional price determination. It allows isolating the regional effects from other international impacts. Hence, eight time-series are evaluated, that are the reference price, Norrköping/Mälardalen, Östergötland and Skåne with both qualities.

Due to the relative size of the Swedish grain market – contributing only 1,18% of Europe's total grain production – it must be considered to be a small country and therefore the analysis allows only limited inference in regard to the influence on European prices.

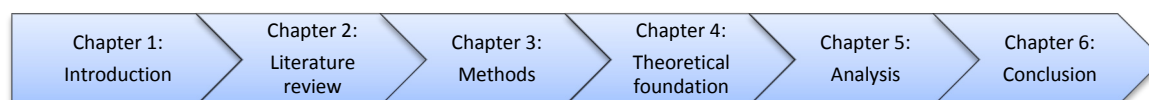
Figure 1.4) Total and relative size of wheat producers in Europe

Rank	Country	Production	%	Rank	Country	Production	%
1	France	40.300.800	20,86%	20	Latvia	1.539.800	0,80%
2	Russian	37.719.640	19,52%	21	Netherlands	1.302.002	0,67%
3	Germany	22.432.000	11,61%	22	Austria	1.275.498	0,66%
4	Ukraine	15.762.600	8,16%	23	Slovakia	1.275.300	0,66%
5	United Kingdom	13.261.000	6,86%	24	Croatia	999.681	0,52%
6	Poland	8.607.600	4,45%	25	Switzerland	516.687	<0,5%
7	Italy	7.767.300	4,02%	26	Moldova	495.231	<0,5%
8	Romania	5.297.748	2,74%	27	Bosnia Herzegovina	225.137	<0,5%
9	Spain	4.650.300	2,41%	28	Former Yugoslawia	214.963	<0,5%
10	Denmark	4.525.100	2,34%	29	Slovenia	188.065	<0,5%
11	Bulgaria	4.455.100	2,31%	30	Luxembourg	79.198	<0,5%
12	Hungary	3.740.000	1,94%	31	Finland	8.871	<0,5%
13	Czech Rep.	3.518.896	1,82%	32	Norway	2.473	<0,5%
14	Lithuania	2.998.900	1,55%	33	Montenegro	2.151	<0,5%
15	Belarus	2.554.160	1,32%	34	Ireland	618	<0,5%
16	Sweden	2.289.300	1,18%	35	Estonia	485	<0,5%
17	Serbia	1.910.914	0,99%	36	Albania	300	<0,5%
18	Belgium	1.738.020	0,90%	37	Portugal	59	<0,5%
19	Greece	1.568.600	0,81%	38	Malta	16	<0,5%
TOTAL						193.224.513	100,00%

Source: World Food Organisation, fao.org,
<http://faostat3.fao.org/faostat-gateway/go/to/download/Q/QC/E>

1.6) Structure

Figure 1.5) Outline



The study is structured in the following way: In the literature review, former studies are mentioned including their contributions and main findings in the field of price transmission. Chapter 3) sheds light on the commonly used methods and the theory behind. It allows choosing a model to evaluate the problem formulation according to the properties of the data. Chapter 4) explains why prices tend to be equal and informs about the suggestions of economic theory on the behavior of prices. In Chapter 5), the econometric model is applied and the data analyzed and interpreted using the methods identified in Chapter 3). Afterwards, the conclusion gives an overview about findings and recommendations.

Chapter 2) Literature Review

Commodities are produced in different regions and different parts of the world. The spatial separation gives rise to extensive literature that is evaluating the prices-relationships between same goods with different origin. The following part gives an overview on research that has been conducted in this field.

2.1) The Law of one price (LOP)

In the literature concerning spatial price analysis the foundation and basic ingredient is the concept of the Law of one price. Thought to be defined firstly by Cassel (1918), the concept shows already up in earlier works, for example in Ricardo (1817) and Marshall (1890). The standard formulation of the Law of one Price states that the differential of prices in spatial markets does not exceed transaction costs; otherwise prices tend to be equal (Protopapadakis and Stoll 1986). Marshall (1890, p.325) says: *“...the more nearly perfect a market is, the stronger is the tendency for the same price to be paid for the same thing at the same time in all parts of the market”*. In a practical example: If trade is present market participants are constantly looking for the best price. Does a price differ more than about transaction costs – that are cost for information and transportation etc. – then the trader would buy that good in the cheaper market, ships it to the other location and sells it with profit (Arbitrage). Because a lot of market-participants see this difference, a higher demand for this good causes the price in the cheaper region to raise until it is exactly the same level as in the others. Generally speaking, if the price in an importing country is the same as in the exporting country plus transportation and other transfer cost there is an incentive to trade (Ravallion, 1986)⁴.

2.2) Spatial market integration

The LOP is the foundation of the analysis of market integration. However, there is no common definition of this term. Earlier approaches define market integration as the degree of co-movement of prices at different locations. In perfectly integrated markets the LOP-definition strictly holds and the prices show the same movements. On the other side, markets are defined as separated if there is no relationship between the prices at all. Practically, market integration is present, if due to arbitrage a price change of a commodity in one region causes the same commodity in another region to change as well.

Fackler and Goodwin (2001, p. 978) propose to think about market integration *“... as a measure of the degree to which demand and supply shocks arising in one region are transmitted to another*

⁴ That is the weak formulation of the LOP. For a discussion on different formulations, see Appendix 7.1)

region". They define a coefficient " R_{AB} " denoting the rate to what extent shocks are transmitted to prices in other regions:

$$R_{AB} = \frac{\partial p_B / \partial \varepsilon_A}{\partial p_A / \partial \varepsilon_A}$$

A hypothetical shock - that is ε_A - occurs in region A, changing the regional price P_A for a commodity. If the market A is perfectly integrated with market B, the shock will transmit to the price of the same good in B (P_B). Then, the ratio will be 1, because the price-change in B is exactly the same as the price change in A. This connection between the markets is called price transmission.⁵ However, the degree expressed by the ratio R does not necessarily mean that it holds in both directions, so it is possible that $R_{AB} \neq R_{BA}$.

An example could be the drought occurring in the United States in 2012. Because of a change in supply, this shock decreased the crop for food-commodities in some parts of the country, causing price-changes in other parts of the world. Having this impact on the price it can be inferred that some degree of market integration must exist (Bjerga 2012).

Two regions do not need to be direct trading partners to show a high degree of price transmission. It is possible that if locations A and B are both trading with region C, all three markets can be highly integrated, even though they are not directly connected by trade. That is, because all three countries are participants of a common trading-network (Fackler and Goodwin 2001).

A lot of research has been done in the field of price transmission and market integration. The earliest works have been written by Mohendru (1937), Cummings (1967) and Lele (1967). All of them estimate correlation-coefficients to examine the wheat market in India. In his study, Mohendru (1937) analyzed four important wheat markets in Punjab/India, examining price data of six months. The closer to one the coefficient is, the higher markets are integrated. His pair-wise measures for market integrations range from 0.43 to 0.86. Cummings (1967) found even higher correlation coefficients. In his book he examined the wheat market in northern India and found correlation coefficients between 0.65 and 0.9. Lele (1967) confirmed the results in a study about the sorghum market in western India and both concluded from their findings that the markets of wheat and sorghum can be considered as highly integrated.

Goodwin (1992) tested the LOP and market integration in international wheat markets. In his analysis, he used the method of multivariate co-integration, as described by Johansen (1988) and

⁵Price-transmission is the "mechanism" of co-moving prices while market-integration is a condition. In this thesis, the terms are often used equivalently

Johansen and Juselius (1990). Co-integration exists if some pairs of time series are following a common drift and move together in the long run. Economic theory proposes different forces holding the series together, such as interest rates, household income and expenditure etc. (Engle and Granger 1987).

“Of 40 tests, 28 reject the LOP, eight have mixed findings, and only four unambiguously cannot reject the LOP” wrote Officer (1989, p. 24). Goodwin’s (1992) intention is that the negligence of transport cost is the reason for this high amount of rejected studies. Considering transport costs explicitly, he tests his theory on wheat export prices in the U.S. Gulf, Australia and some Canadian ports and import prices in Rotterdam and Japan. He concludes, that there is a relationship between wheat prices in international markets, confirming the LOP in a long-run perspective. The study emphasises the importance of transport cost in the literature dealing with market integration. In an examination of wheat-prices in the US, Rotterdam and Japan the results have been confirmed by Michael et al. (1994).

There are other methods with which one can evaluate price transmission. Ravallion (1986) developed a coefficient similar to Fackler and Goodwin’s (2001) to determine the degree of integrated markets. Furthermore, Causality test as described by Granger (1969) have often been used to find cause-and-effect relationships of different prices. In Chapter 3) these methods are explained in detail.

As a conclusion, it is to say that the theory behind the LOP as basis of market integration has its authorization in a long term sense even though it cannot always be doubtlessly verified. Price transmission is evaluated in this context, to find out to what extend different prices in Sweden move together and if they tend to have the same price. If this is known, it would be possible to examine what price-effect the expansion of the plant in Norrköping had had on the other prices. The following table gives an overview of important works from the sixties to more recent studies on price-transmission.

Table 2.1): Literature and findings on Spatial market integration of different agricultural commodities

Author	Method	Findings
Jasdanwalla (1966)	Correlation analysis	Evaluated spatial linkages between local markets and terminal markets of groundnuts using correlation analysis. Stronger correlation coefficients take place among terminal markets than among terminal and local markets.
Granger and Elliot (1967)	Granger causality	Evaluated the English wheat market in the 18 th century. They found that already back then significant interactions between the markets took place.
Takayama and Judge (1971)	Autoregression	Price series in different markets have an own autoregressive structure. However, they show dynamics with market prices from a certain key market. Takayama and Judge coin the expression of long-run and short-run market integration, defining the period in that prices move together.
Heytens (1986)	Ravallion test of market integration	Looks on the market for ginger and yams in Nigeria and finds a lack of integration that is improving over time for ginger, while the yams markets are less integrated. Heytens traces this back to high storage costs related to yams which are increasing the transaction costs, finding that treating transaction costs in a wrong way or not at all has huge impacts on the regression results.
Gardner and Brooks (1994)	Geographical price differences	Examining price data from the former soviet union, Gardner and Brooks found that price transmission ratios are affected by the distance between markets as well as different regional policies.
Goodwin and Piggott (2001)	Impulse response	Finding strong support of market integration in corn- and soybean-markets in North Carolina. Furthermore, shocks are being transmitted dynamically over time. Threshold behaviour of market participants exists, that means larger shocks show different dynamics of price transmission in magnitude and speed than smaller shocks.

2.3) Spatial market efficiency

If the LOP and therefore some degree of market-integration between locations exists, shocks in geographically separated regions have an impact on the market-prices of other locations. To answer why this is the case leads to the term of spatial market efficiency or what markets conditions have to be present that they are well connected. Generally, the more efficient markets are, the higher they are integrated. Scientists have identified some reasons why market prices show a higher or lower degree of market integration:

First of all, markets should be able to produce prices that reflect all information available. That means information about conditions and factors affecting the demand and supply, but also information about transaction costs has been included in the price setting process. Directly linked to information and the degree of market integration is the amount of information available in other locations. If market participants have perfect information about the prices in other regions they are able to identify and exploit arbitrage opportunities faster and easier (Fama 1991).

The second common factor is the amount of transaction costs. Heytens (1986) found that if they are treated wrongly, they may have a big impact on regression results. Transaction costs can be high because of reasons lying far away from individuals influence. That is for example the poor execution of contracts, insufficient law enforcement, corruption, missing or deficient communication- and transport-infrastructure or excessively high taxes. Especially developing countries encounter these problems leading to inefficient and partly not well integrated markets (Fackler and Goodwin 2001).

A third factor is the distance between two markets. Gardner and Brooks (1994) found that with increasing distance between regions or countries the degree of price transmission decreases due to higher transportation- and transaction costs. However, in the last decades the transportation- and information infrastructure increased tremendously, so that their findings might be of less magnitude on today's trading patterns.

The concept of efficient markets is going hand in hand with perfect competition. In a market with perfect competition, the market participants are price takers and not able to influence the prices for a homogenous good. In markets showing oligopolistic or monopolistic structures, the market-size as well as prices and market-access are often determined by a few or a single company and that are mostly restricting and negatively influencing market integration (Stigler and Sherwin 1985). The following table gives an overview of the findings researchers found in the field of market efficiency.

Table 2.2) Literature and findings concerning market efficiency

Author	Method	Product	Findings
Stigler and Sherwin (1985)	Price movement tests	Wheat, Flour, Gasoline, Petroleum products	Find that monopolies affect markets in size, price and access borders. This affects the time dimension of the movement of prices.
Buccola (1989)			Discusses the general definition of price efficiency. Efficiency in prices is the optimal allocation of resources that maximizes the individual's utility of output, subject to the available stock of resources.
Goletti and Christina-Tsigas (1995)	Cointegration coefficients, Time series analysis	Maize	Analyzes several methods to measure market integration and market efficiency on the maize market in Bangladesh and Malawi. Identifies marketing infrastructure, governmental policy and dissimilarities on production level as determinants for efficient markets. Overcoming structural deficiencies is mostly the reason for an enhancement in the speed of price transmission and in the level of market integration.

2. 4) Types of market integration

The most of the literature discussed above is dealing with symmetric price transmission. That is the case, in which if prices in a market change prices in another integrated market change in the same direction.

Asymmetric price transmission is the phenomenon that prices behave asymmetric to price changes. A typical example is the oil and fuel market. Fuel-prices seem to react almost immediately to increases in crude-oil prices, while in case of a decrease the retail prices for fuel decline only moderately. This negative asymmetric price transmission has significant impacts on the welfare of consumer (Wlazlowski 2001). However, positive asymmetric price transmission exists as well, when for example upstream product-prices react faster on a decrease of the input-factors than they do on an increase of input-factors. The reason for asymmetry price behaviour has been identified in inefficient markets, especially in the presence of centralized market power and can often be found in vertically integrated markets (Ward 1982, Meyer and von Cramon-Taubadel 2004).

Peltzman (2000) evaluated 282 different products and commodities and finds asymmetric price transmission to occur regularly in commodity markets and concludes failure of economic theory, due to a lack of explanation. However, asymmetric price transmission is often a phenomenon of vertical integrated markets. This study aims to evaluate the impact of a specific shock and therefore the analysis of asymmetric price transmission is not relevant in this context.

2.5) Critics on common methods

Most studies conclude that some relationship exist between prices for some goods in some markets. However, common approaches have been criticised. Harriss (1979) wrote that it is important to distinguish the concepts of market integration and other forms of integration. An example is the economical integration of an area in the sense of no border restrictions, which represent obstacles for goods but are not integrated in any specific market. In a practical example, a highly perishable crop is only produced for regional consumption. That infers that transaction costs are too high, so that no trade occurs and hence markets are not integrated. However, co-movement of two prices in two regions can be found, if the same price setting behaviour of producers and/or same demand - supply patterns exists.⁶

2.6) Summary and significance for the study

The analysis of spatially separated markets has a long history and has been subject to a lot of further research. The theoretical foundation of all studies is the Law of One Price, which states that in integrated markets the price difference between two prices is only determined by transaction costs, occurring from moving one commodity to another market. Otherwise, the prices are equal. In empirical studies, the LOP could not be proved beyond doubt, however, scientists found that a relationship between prices exists at least in the long- run.

The best fitting definition of market integration for this study is provided by Fackler and Goodwin (2001) as a degree of how shocks are transmitted to other markets. Reason for this transmission is the exploitation of arbitrage possibilities, that are linked to the LOP.

The circumstances in which market integration basically can be found in are connected to how markets show efficiency to determine prices and provide information. Those are markets where agents are using all available information about supply and demand, are facing reasonable transaction cost and show decentralized market power. However, as Gardner and Brooks (1994) found, distance between market places does play a role in the degree of integration.

⁶ That is referred to as climatic integration

The relevance for this study is given by the definition of market integration, that shocks are transmitted to integrated markets. However, there are no studies empirically evaluating specific shocks and their impacts on Swedish markets. The literature mainly focuses on the question if market integration can be observed and why. From the theory evaluated in this chapter, it is expected that the Swedish grain markets are highly integrated, due to strong competition between producers, a high degree of available information, a distinctive infrastructure, low transaction costs and regional adjacency. If this is the case, the supply shock initiated by the inauguration of the ethanol plant in Norrköping must be transmitted to all markets.

Chapter 3) Methods

If shocks transmit to other markets and prices show a certain co-movement, they are said to be integrated. The following chapter provides an overview on different methods of measuring price transmission and their theoretical foundation.

There are three major categories that measure market integration. In this chapter the most relevant methods are discussed which are commonly used in the past and therefore have a lot of support in economic research. They are:

- 1) Correlation- and regression-analysis
- 2) Dynamic regression models
 - 2.1) Granger causality
 - 2.2) Ravallion/Timmer market integration criteria
 - 2.3) Cointegration analysis
 - 2.4) Impulse response
- 3) Switching regime models

3.1) First category: Correlation- and Regression-analysis

As used by Mohendru (1937), Cummings (1967) and Lele (1967), correlation analysis is the earliest form of analyzing market integration between spatially separated markets. The idea of correlation can be dated back to the 1888, when the scientist Francois Galton found a common behavior in three different problems he was evaluating. Pearson (1895) took up the idea and developed the Pearson product-moment correlation coefficient (Stigler 1989).

The correlation coefficient in a population is statistically determined by the formula:

$$\rho = \frac{Cov(X,Y)}{\sigma_X * \sigma_Y}$$

where $Cov(X,Y)$ is the covariance between two variables X and Y , and $\sigma_{X/Y}$ the standard deviation. If ρ equals $+1$ and the variable X increases, the other variable Y is doing exactly the same. However, if ρ equals -1 an inverse relationship between the variables holds. That means, if the variable X increases, the other variable Y decreases. If $\rho = 0$ there is no relationship between the prices at all (Stock and Watson 2010). Studies using correlation analysis test the sample correlation coefficients on significance, so they test $H_0: r = \text{a certain value}$, against the alternative of $H_1: r \neq \text{a certain value}$.

Another method to evaluate price transmission is regression analysis. Doing so, the analyst regresses the price in one region P_{1t} on the price of another region P_{2t} plus transaction costs T_t as well as other reasons that contain price-difference effects (denoted by R_t):

$$P_{1t} = \alpha + \beta_1 P_{2t} + \beta_2 T_t + \beta_3 R_t.$$

In perfectly integrated markets the parameter values are $\beta_1=\beta_2=1$ and $\alpha=\beta_3=0$. Inserting the values would then lead to the equation: $P_{1t} = P_{2t} + T_t$. That refers to the assumption that the prices do only differ by transaction costs and no other factors, captured in the terms R_t and α (Richardson 1978).

Both tests are intuitive, easy to conduct and to understand. However, misleading results have been reported when using non-stationary data⁷. Furthermore, the correlation-analysis does not allow for determining causality – that is the cause-effect-relationship - and it is very difficult to conduct in regression-analysis.

3.2) Second category: Dynamic regression models

The dynamic regression models are the most developed and base on time series techniques. Time-series techniques do typically mean that autoregressive models are used (VAR's, AR's). The price of a commodity today is regressed on previous observations to model lagged effects. That is credible due to delivery lags, trade impediments or other dynamic effects that may occur. A general, underlying vector autoregressive process (VAR) may be described by:

$$A_0 P_t = \sum_{k=1}^n A_k P_{t-k} + DX_t + e_t. \quad (\text{Eq. 3.1})$$

In that model, P_t is a vector of prices, X_t a vector of price-influencing regressors, A_i and D are coefficient matrices and e_t the vector of error-terms. The indices t and k denote time and lag-length. The error-terms are assumed to be exogenous and serially independent. They represent unobservable market shocks (with the covariance-matrix $\text{cov}(e) = \Sigma$).

Typically, Granger causality, the Ravallion/Timmer market integration criterion, co-integration analysis and impulse response analysis use Autoregressive models.

⁷ Data that is containing stochastic trends

3.2.1) Granger-causality

Granger causality tests are typically using VAR-modeling, with the exception that the price in one region is regressed upon lagged prices in other markets. If the coefficients are significant, the lagged prices of other markets have an influence on the current market price in the tested region (lead/lag-relationship, called Granger-causality). Granger (1969) reformulated Equation 3.1), using $A_0 = I_n$ (the identity-matrix) and without other price-influencing regressors, X_t . He express' a reduced form of the model and tested that some elements of the coefficient matrix are zero, to determine which price follows another if a price-change occurs. Granger causality does nothing say about the reasons that lead to dynamic adjustments but is a helpful tool to determine a lead/lag-relationship (Fackler and Goodwin 2001). The economic interpretation of Granger-causality is only that if causality exists between two variables, the lagged values of a variable or price X provides statistical significant forecasting information on another price or variable Y (Granger 1969).

However, as Gupta and Mueller (1982) argued there might be problems, if causality is not running in one direction but unidirectional, that means from one price to another and vice versa. Furthermore, this method may allow inference for the existence of some statistically significant lead/lag-relationships but the actual nature of the relationship is – without further testing – not evaluated.⁸ The test itself could indicate some sort of connection even though it is inconsistent with the theory of market integration. Therefore, the uncritical interpretation of Granger-causality tests might lead to wrong inference on markets' spatial integration. Nevertheless, Granger causality is an often used concept within other methods evaluating price transmission.

3.2.2) Ravallion/Timmer market integration criteria

Ravallion (1986) and Timmer (1987) tested market integration in a dynamic context. Ravallion (1986) use a reduced form of an autoregressive model,

$$P_{it} = \sum_{s=1}^n A_{is} P_{it-s} + \sum_{s=0}^n B_{is} P_{1t-s} + D_i X_{it} + e_{it} \quad (\text{Eq. 3.2})$$

in which P_{it} is the regional price, P_{1t} a leading or central market and X_{it} a vector of influencing factors and A, B, D vectors to be estimated. An important assumption is that a leading market exists, that is used as price-determining or reference-price for other markets. That means, there is a big, central market on which others are orientating. The prices in the other markets, let us say hinterland

⁸ Typically, further testing is usually the estimation of a VECM

markets, are influenced by this reference market plus additional regional factors X_{it} . Ravallion (1986) tests three different kinds of market integration, depending on the formulation of the H_0 -hypothesis:

- 1) Short-run integration, which implies that shocks between the central and regional markets are directly and abruptly transmitted to the other prices
- 2) A weaker form of short-run integration, where lagged effects vanish on average
- 3) Long-run integration where market prices are equal over time.⁹

Timmer (1987) used another model, using first differences of one central and different regional markets, defining an index (IMC) that measures the degree of market connectivity. If the integration is high and the markets are highly connected, the IMC is close to zero.

However, both integration criteria are sensitive to existing and high transportation/transaction cost, but they may be useful if independent confirmation is available that transport rates are random white-noise processes (Fackler and Goodwin 2001). The disadvantage of this analysis is that it defines a degree/status of market integration but does not allow for inference on the relationship between prices.

3.2.3) Co-integration analysis

The predominant method of analyzing spatial market integration is the co-integration analysis. As Nelson and Plosser (1982) found out, most of macroeconomic time series are incorporating trends or wander extensively in time, then they are non-stationary and incorporate trends/a unit-root. Therefore, the analysis of market integration had to be reconsidered to deal with the implications of unit-root processes in time series.

Typically, co-integration tests evaluate the equilibrium parity condition, implied by spatial arbitrage:

$$P_{1t} - \alpha - \beta P_{2t} = \varepsilon_t \quad (\text{Eq. 3.3})$$

P_1 and P_2 represent two prices in spatially separated markets. Assumed that they are non-stationary, the standard errors of the regression-parameters α and β - obtained from regression estimates - are not consistent and therefore do not allow for sufficient inference. Co-integration tests, however, consider the time series properties of the residual term ε_t . If the prices wander around the same trends and the residuals are stationary, that implies that both time series are linked in a stable and long-run equilibrium (Engle and Granger 1987). In other words: If p_1 and p_2 are showing almost

⁹ It may be noted that that short-run integration requires long-run integration to be present, but not the other way around

perfect co-movement and α and β are assumed to be constant, then the error terms ε_t is white noise and does not trend. In this case, β is called the co-integration vector.

An advantage of this kind of analysis is the possibility to evaluate a number of n-prices. Then, if the markets are integrated, there are n-1 co-integration relationships and all variables follow common trends.

These multivariate co-integration tests are usually conducted within the framework of a reduced VAR-model (see Eq. 3.1), in which the prices are regressed on their own lagged values:

$$P_t = A_1 P_{t-1} + A_2 P_{t-2} + \dots + A_k P_{t-k} + v_t \quad (\text{Eq.3.4})$$

Engle and Granger (1987) estimated Eq. 3.3.) with an Ordinary Least Square (OLS) procedure, while Johansen (1988) and Johansen and Juselius (1990) used a full information Maximum Likelihood-method on the first differences of Eq. 3.4).

Engle and Granger's co-integration test evaluates if the error-term ε_t is containing a unit-root, that means applying a suitable test to the data (such as ADF). If there is evidence for stationarity of ε_t , the prices can be seen as co-integrated in the long-run. That means if the error-term is found to be stationary and white noise the markets show a co-movement of prices. Johansen (1988) on the other hand derived the distributions of two tests, the Eigenvalue- and Trace-test and developed a test to find if co-integration between the variables is present.

Engle and Granger (1987) alleged in their paper that if two variables are individually co-integrated of degree 1, there exists at least a one-directional causal relationship (Granger-causality). The relationship can be validly estimated by an Error Correction Model (ECM). This is called the Granger-representation-theorem. Engle and Granger (1987) define a mathematical model, which captures short- and long-run-effects and allows for adjustment of the prices. However, before the model can be validly estimated, a long-run relationship between the time-series has to be assumed. Because it is possible that prices do not move together in the short run, the definition of short-run- and adjustment-effects is necessary to model these temporary differences.

The ECM of two integrated prices can be expressed by:

$$\begin{pmatrix} \Delta P_{1t} \\ \Delta P_{2t} \end{pmatrix} = \begin{pmatrix} \mu_1 \\ \mu_2 \end{pmatrix} + \begin{pmatrix} \alpha_1 \\ \alpha_2 \end{pmatrix} (P_{1t-1} - \beta P_{2t-k}) + A_1 \begin{pmatrix} \Delta P_{1t-1} \\ \Delta P_{2t-1} \end{pmatrix} + \dots + A_k \begin{pmatrix} \Delta P_{1t-k} \\ \Delta P_{2t-k} \end{pmatrix} + \begin{pmatrix} v_{1t} \\ v_{2t} \end{pmatrix} \quad (\text{Eq. 3.5})$$

The model is written in first-differences to eliminate statistical integration of degree d (denoted as $I(d)$). The matrices A_1 to A_k are captureing the short term effects on the prices. As in Eq. 3.4.), β is

the co-integration vector and incorporates the long-run equilibrium relationship between the series. The vector including α_i allows for error-corrections in the short run, which are price differences that may occur before prices tend to move back to their long-run-equilibrium.¹⁰ Another less technical expression for the error-correction coefficient could be speed of adjustment that allows for interpreting the time that the market needs to implement adjustments to new market conditions. The closer α_i is to 1, the faster the market reacts to disturbances. However, it is also possible that the error correction coefficients are estimated to be close to -1. In this case, it allows inference on to which extend distortions like policies or transaction costs prevent the adaption from short-term movements to the long-run-relationship (Rapsomanikis et al. 2003).¹¹

In the framework of the Error Correction Model, Granger (1988) mentions, that the existence of co-integration between two time series implies Granger-causality in at least one direction. However, the concept of co-integration does not allow for inference on the direction of causality, therefore causality-tests are often included in the analysis of this method.

The error correction model can be estimated to evaluate if market integration can be statistically determined between prices, using dynamic factors such as the speed of adjustment or effects in different time-perspectives. However, finding integrated markets using this model does not allow for inference on the efficiency of the markets. In models with stable trade patterns the spread between prices are mostly transport rates and transaction costs. Nevertheless, if transport- and transaction costs are vulnerable to trending behavior as well, a co-integration relationship between prices does not necessarily emphasize good arbitrage conditions (Goodwin 1992).

Overall, this model is sufficient to confirm a relationship between prices and to estimate dynamic patterns, such as long- and short-run behavior. The estimation of parameters is one advantage of this method, allowing for inference how markets react quantitatively to shocks (Fackler and Goodwin 2001).

3.2.4) Impulse response analysis

The impulse response analysis shows how markets react if shocks occur in one market, represented by a Moving-Average AR-model (ARMA). Impulse response functions are used to determine the dynamic effects related to market integration and they allow for better inference on the dynamics of

¹⁰ In VECM's the long-run-relationship is estimated, that are the elasticities between two prices. If the elasticities are close to one, the markets show the same price movements and therefore are perfectly integrated

¹¹ Appendix 7.3) is giving an in-depth explanation on the ideas and derivation of VECM's

adjustments to price shocks. In other words, Impulse response functions show what happens to other markets, if a shock of one unit occurs at a certain trading place.

The advantage is that specifically shocks and their dynamic patterns are evaluated, while no inference or estimation of a long-run relationship is conducted.¹²

3.3) Third category: Switching regime models

The switching regime models base on the techniques by Goldfeldt and Quandt (1973) who invented Markov-switching-models in econometrics. The problem with dynamic approaches to test co-integration exhibit the lack of a missing, clear alternative to the null-hypothesis of perfect market integration. This becomes a problem for the testing procedure, if markets are imperfectly integrated and the trading patterns change over time. This could be the case if seasonal influences are twisting the trade flows. For example a country is a major exporter for a good in summer, but a major importer of the same good during winter. Timmer (1987) suggested that this switching regime may lead to difficulties in the identification of market integration.

Switching regime models are a modern approach and have not been used extensively. Different definitions of Null-hypothesis determine the Regime, that means the direction of trade flows and allow for switching patterns as well. However, in the context of this thesis this method is not of further relevance.¹³

3.4) Method used in this study

Because of the favorable properties, methods of the second-category are used to analyze price transmission in Sweden. That includes Granger causality tests, Johansen co-integration-tests, the estimation of elasticities via VECM and Impulse response functions. The purpose of using these methods is that the advantages of some methods compensate for some other method's disadvantages.¹⁴ Additionally, using a combination of models provides a whole-picture-view.

Advantages are the use of time-series and quantitative estimation of relationships, which allows for analyzing the exact impact of the plant and does not only give a degree of market integration (such as Ravallion/Timmer and correlation-analysis). Disadvantage is the relative importance of transaction-costs that have not been considered in this study.

¹² A comprehensive explanation can be found in Appendix 7.2)

¹³ The interested reader finds a comprehensive explanation in Appendix 7.4)

¹⁴ For example, Granger-causality-tests do not estimate a quantitative relationship which is compensated for by using a VECM-approach.

Chapter 4) Theoretical framework and econometric approach

In the literature review the law-of-one-price is identified as an invisible force influencing the prices in spatially separated regions: *“The more nearly perfect a market is the stronger is the tendency for the same price to be paid for the same thing at the same time in all parts of the market”* (Marshall 1890, p.325). Besides that, markets can be considered integrated, even if they are not trading directly. That is if they are connected through a common trading network. Then, for example two markets - A and B - can show price co-movements if their trading-activity is connected through a third market C.

Different theoretical frameworks exist, explaining the LOP under different market conditions:

- 1) Point-location models: These types of models explain the LOP if different markets are connected through a node/market. That can be major processing-, distribution or collection-center or if a terminal-market-structure exists, like in the gas- or oil-market.
- 2) Agent-on-links models: While the point-location-models deal with market-networks, the agent-on-links-models are majorly used in the framework of market power, which is, if a few oligopolistic firms compete for business provided by agents on link-positions.
- 3) Sequential equilibrium models: These models include dynamic linkages such as storage, delays, investment or seasonality. Dynamics are treated as exogenous events and the prices in different markets are determined by several static equilibria. The prices are continuously influenced by shifts in demand and supply functions.

In this analysis Point-location models fit best in the supply- and demand-context of the plant and an assumed long-run equilibrium as estimated by a VECM. The models have been described by Enke (1951) and Samuelson (1952) and further developed by Takayama and Judge (1964a, 1964b, 1971).

The theoretical framework considers two or more markets for a given product. Transport cost exists between the markets, which are costs to move the good - in our case wheat - from market A to B (shipping-, insurance-cost and duties etc.). Furthermore, all markets have an own market price, as well as own supply- and demand functions.

In the following analysis we denote the region with indexes A=Norr, B= Öst, C= Skåne and D= France:

P_A = Price of grain in the region Sweden Norrköping/Mälardalen

P_B = Price of grain in the region Sweden Östgötaland

P_C = Price of grain in the region Skåne

P_D = Price of grain in France.

Furthermore, constant transport costs T_{ij} exist. The index i denotes the origin while the index j denotes the destination of the commodity wheat. To simplify the theory a two-location model is explained. The model is used to show under which circumstances a commodity is exported or imported in which region and what impact that has on the prices.

4.1) Incentives to trade and the law-of-one-price

Because every region has its own Supply- and Demand-curve the price in a perfect competitive market is determined at the intersection of demand- and supply-curves. At that point, the producer surplus is maximized. That leads to two prices in each region that are different to each other (Autarky-prices) (Koo and Kennedy 2004).

When including the possibility to trade, the two markets do have the opportunity to market their goods in another market. Reasons for this may be better marketing opportunities or higher prices. Then, one region exhibits an excess supply and the other an excess-demand. The local demand remains unsatisfied in the market that shows an excess demand (-ES), which is satisfied by the exported goods of the other region that shows an excess supply (ES). The ES-function can be mathematically expressed by:

$$\text{Local Supply} - \text{Local Demand} = \text{ES}.$$

If supply cannot satisfy the local demand, the market is experiencing an excess-demand due to a “missing” amount of goods. The ES is then smaller than zero. Because $\text{ES} = -\text{ES}$ a negative excess supply can be expressed as excess demand.

In the trade situation, the market is opening and can be extended by an international trading market. All excess supplies and demands are aggregated to determine the world price. Due to arbitrage, trading opportunities in one region are instantly exploited and therefore the local prices adapt to international prices (Koo and Kennedy 2005). Then, the situation can be extended by a third graph denoting the quantities of traded goods. From this aggregated demands and supplies the new equilibrium price can be determined, that is Point C in Figure 4.1).

Figure 4.1) Price determination in a partial equilibrium framework

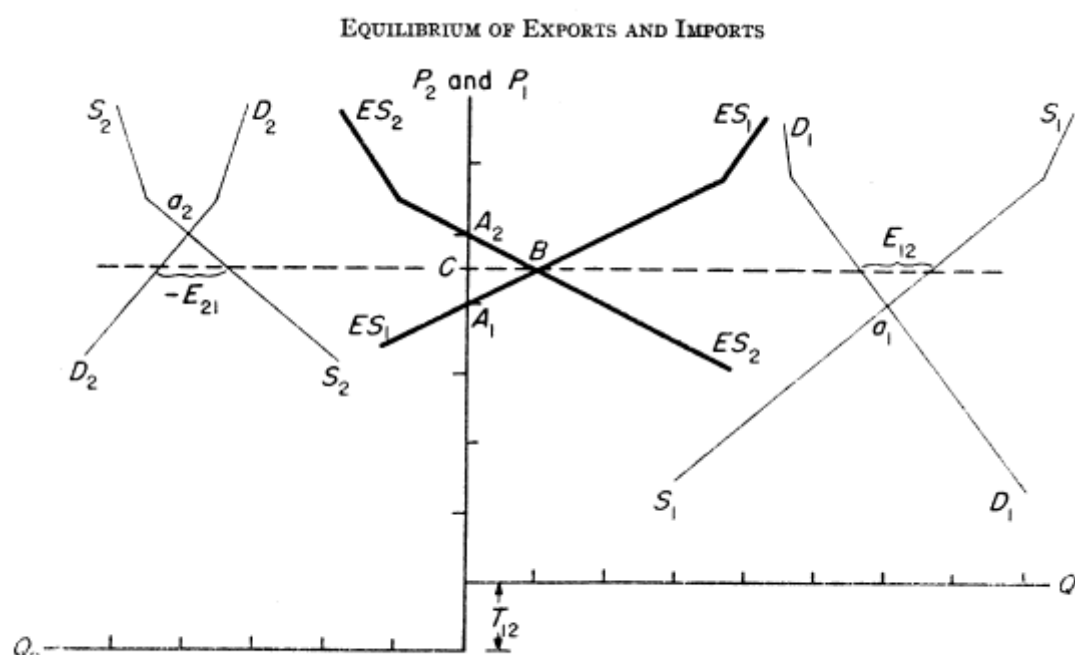


FIGURE 1. Equilibrium is at B where exports of 1 match imports of 2 at the differential between P_2 and P_1 equal to transport costs, T_{12} . Note shift in lower axis of 2.

Source: Samuelson, P.A., 1952. *Spatial Price Equilibrium and Linear Programming*. *The American Economic Review* 42, p.286

Before trade, the equilibrium is determined at the demand- and supply-intercepts with prices A_1 and A_2 . The excess supply in these situations is zero in both cases. After opening the market, arbitrage causes the price to change (the world price, Point C) and the respective quantities are given by the intercept of the excess-supply curves ES_1 and ES_2 .¹⁵ Note that the shift in axis in the figure is due to transport cost.

Extending the model by transport cost, the equilibrium-conditions on prices are given by

$$P_2 = P_1 + T_{12} \quad (\text{Eq. 4.1})$$

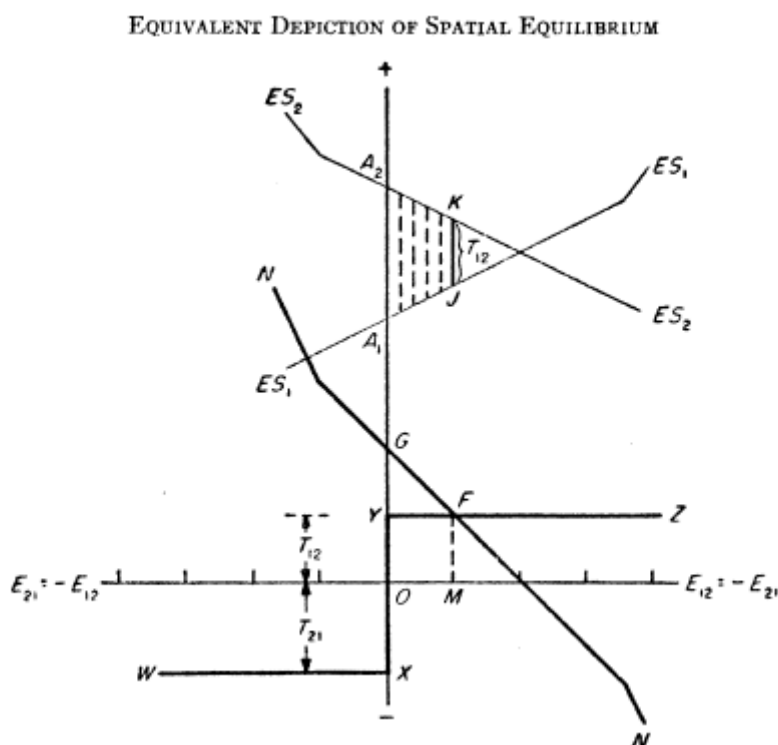
$$P_1 = P_2 + T_{21} \quad (\text{Eq. 4.2})$$

If Eq. 4.1) and 4.2) hold, there may be an exchange of goods ($E_{12} \geq 0$ and $E_{21} \geq 0$). On the other hand, $E_{12} > 0$ imply that Eq. 4.1) holds, because then trade takes place and arbitrage opportunities are directly exploited.

¹⁵ The slope of the Excess supply of one country is negative, because it is an Excess demand

The situation in the trading market changes, because the price is additionally affected by transport costs. Then, the equilibrium changes to the point where the curve of transport costs (line WXYZ) in Figure 4.2) intersects with the net excess-supply N.

Figure 4.2) The import-export market including transport costs



Source: Samuelson, P.A., 1952. *Spatial Price Equilibrium and Linear Programming*. *The American Economic Review* 42, p.287

In Figure 4.2), the same excess-supply curves are applied but the shift of the axes is compensated by explicitly showing the transport cost, that is T_{12} and T_{21} . Y and X denote the prices in the respective region without transport cost. The effective trade quantity is then point M.

But why are the markets trading? Obviously they are realizing a higher net-welfare as in the autarky situation. Introducing a social pay-off function and assuming it to be the area under the excess-demand curve of each region, the net social pay-off is:

$$\text{NSP} = \text{Social pay-off in region 1} + \text{Social pay-off in region 2} - \text{Transport cost} \quad (\text{Eq. 4.3})$$

The NSP can be measured as area under the N-curve, OMFG. At the point F with traded quantity M, the net social payoff is maximized (Samuelson 1952).

This model can be extended by n different markets and the equilibrium is obtained by applying linear programming techniques. Every region is assumed to be connected via a trading path that is denoting the imported quantities and different but constant transport cost T_{ij} with $i, j = \text{all regions}$.

It is to note that the markets do not have to trade directly with each other in order to achieve the trade equilibrium in the model. Due to the international market captures all exported and imported quantities, a region – lets say A – that is only producing may satisfy its demand through imports of market B. In turn, market B is exporting quantities that have been imported from C. Therefore, A and C are connected through B and all are participants of a common trading network.

This situation is showing pretty good how prices tend to be equal if international trade is possible. If a connection like Eq. 4.1) and Eq. 4.2) is present, the markets can be considered to be integrated. However, this model shows an extreme case assuming perfect markets. Especially in the short run prices are in practice often moving differently, even though they show a tendency to the equilibrium conditions in the long-run. This is the case if the assumptions of a perfect market are violated. (Rapsomanikis et al. 2003).

4.2) The theory of co-integrated prices

Most of the studies dealing with co-integration analysis test some form of LOP. This can be formulated by the equilibrium parity condition that is implied by spatial arbitrage:

$$p_{1t} - \alpha - \beta p_{2t} = \varepsilon_t \quad (\text{Eq. 4.4})$$

As before, β is referred to as co-integration-vector.¹⁶ The analysis of the error-term regarding its time-series patterns is the foundation of typical co-integration tests. If different prices are integrated the term ε_{it} is a stationary process with constant mean. That implies that even though the price p_1 and p_2 wander on their own in the short run, they are showing a constant long-run-relationship with stable equilibrium. Depending on how much prices are evaluated, a group of n prices should have $n-1$ co-integration relationships (Fackler and Goodwin 2001). In our case four prices are given so that three co-integration relationships exist:

$$p_{At} - \alpha_1 - \beta_1 p_{Bt} = \varepsilon_{1t} \quad (\text{Eq. 4.5})$$

$$p_{Bt} - \alpha_2 - \beta_2 p_{Ct} = \varepsilon_{2t} \quad (\text{Eq. 4.6})$$

$$p_{Ct} - \alpha_3 - \beta_3 p_{Dt} = \varepsilon_{3t} \quad (\text{Eq. 4.7})$$

¹⁶ The co-integration-vector may be thought of as “force” that makes sure that prices are not moving too far away from a certain pattern

Note that even though there is no explicit relationship given for all prices in the equations 4.5 – 4.8, plugging the equations into each other implies that there is a relationship between all of them. In other words: All three equations are linked among themselves.

Engle and Granger (1987) define a series x_t to be integrated of degree d , if the series has a stationary, invertible, ARMA-representation after differencing d times, denoted $x_t \sim I(d)$. That means, if a variable x_t is $I(1)$, it is stationary and invertible after differencing one time (that is: the variable $z = x_t - x_{t-1}$ is $I(0)$).

Furthermore, if all elements of x_t - which are different price series - are $I(d)$, “the components of the vector x_t are said to be co-integrated of order d , b , denoted $x_t \sim CI(d,b)$; 17 then, there exists a vector (...)” $\beta (\neq 0)$ that is called co-integrating vector and an error-correction-representation exists in the system (Granger-representation theorem) (Engle and Granger 1987, p.253). This error-correction-representation is given in the two-market case by the formula:

$$\begin{pmatrix} \Delta P_{1t} \\ \Delta P_{2t} \end{pmatrix} = \begin{pmatrix} \mu_1 \\ \mu_2 \end{pmatrix} + \begin{pmatrix} \alpha_1 \\ \alpha_2 \end{pmatrix} (P_{1t} - 1 - \beta P_{2t} - k) + A_1 \begin{pmatrix} \Delta P_{1t-1} \\ \Delta P_{2t-1} \end{pmatrix} + \dots + A_k \begin{pmatrix} \Delta P_{1t-k} \\ \Delta P_{2t-k} \end{pmatrix} + \begin{pmatrix} v_{1t} \\ v_{2t} \end{pmatrix} \quad (\text{Eq. 4.8})$$

The error-correction-representation is describing the long-run-patterns of a price-series p_t . The advantage of the model is that it allows for short-run-differences among the prices but assumes a stable long-run relationship. The effect of the different variables on each other is estimated by using econometric estimation.

In this case, it would be the price-effect of a reference price D on the prices at the locations A , B and C . Because this study evaluates the connection between four prices, Eq. 4.8) can be simplified by:

$$\Delta P_{A,t} = \alpha + \theta(P_{A,t-1} - \beta P_{D,t-1}) + \delta \Delta P_{D,t-1} + \rho \Delta P_{A,t-1} + \varepsilon_t \quad (\text{Eq. 4.9})$$

$$\Delta P_{B,t} = \alpha + \theta(P_{B,t-1} - \beta P_{D,t-1}) + \delta \Delta P_{D,t-1} + \rho \Delta P_{B,t-1} + \varepsilon_t \quad (\text{Eq. 4.10})$$

$$\Delta P_{C,t} = \alpha + \theta(P_{C,t-1} - \beta P_{D,t-1}) + \delta \Delta P_{D,t-1} + \rho \Delta P_{C,t-1} + \varepsilon_t \quad (\text{Eq. 4.11})$$

The coefficients $\alpha, \theta, \beta, \delta$ and ρ are estimated parameters. The equations describe the price differentials in the regions A , B and C , if the reference-price in D changes.¹⁸ They have the following interpretation:

¹⁷ d is the degree of integration, whereas b the degree of co-integration. Typically, this is $d=1$ and $b=1$ in the two markets case and $b=n-1$ in the n -market case

¹⁸ Vice versa, if the equations are inverted

α : Trend parameter

β : The co-integration relationship between the variables. It can be interpreted as long-run relationship or long-run elasticity between the prices

θ : Reflects the speed of adjustment to the long-term equilibrium, depending on how fast prices adapt. It typically lies between $-1 < \theta < 0$. The term following in parentheses is the error existing between the price of the previous period and the long-run-relationship. The closer it is to -1 the quicker the adaption of P_i is to its long run relationship with price D

δ : Reflects the change in the price D and can be interpreted as short-run elasticity of P_i relative to the reference price P_D

ρ : This parameter reflects the magnitude of change in P_i on future values. It describes what impact a price-change has on its future values. Typically this value lies between -1 and 1 (Minot 2011).

4.3) The importance of the reference price

The analysis of spatial prices is examining to what extent prices show a joint movement. It allows inference on the transmission of shocks and how prices react to certain events. In this analysis, a reference price is needed due to the fact that market participants often orientate on this price to interpret the value of their goods relative to other markets. A farmer at a certain spatial location will compare the prices of the goods he intends to sale, in order to maximize his welfare. According to the Swedish Competition Authorities the Swedish grain price is mainly influenced by world market prices (Persson 2011).

Another reason why the reference price is need is that the problem formulation aims at the detection of how prices changed due to the plant. That implies the analysis of relative price changes, because the markets could have been falling after the inauguration. Then, relative price-changes show if the price in Sweden became relatively more expensive due to a positive demand shock, compared to the reference price.

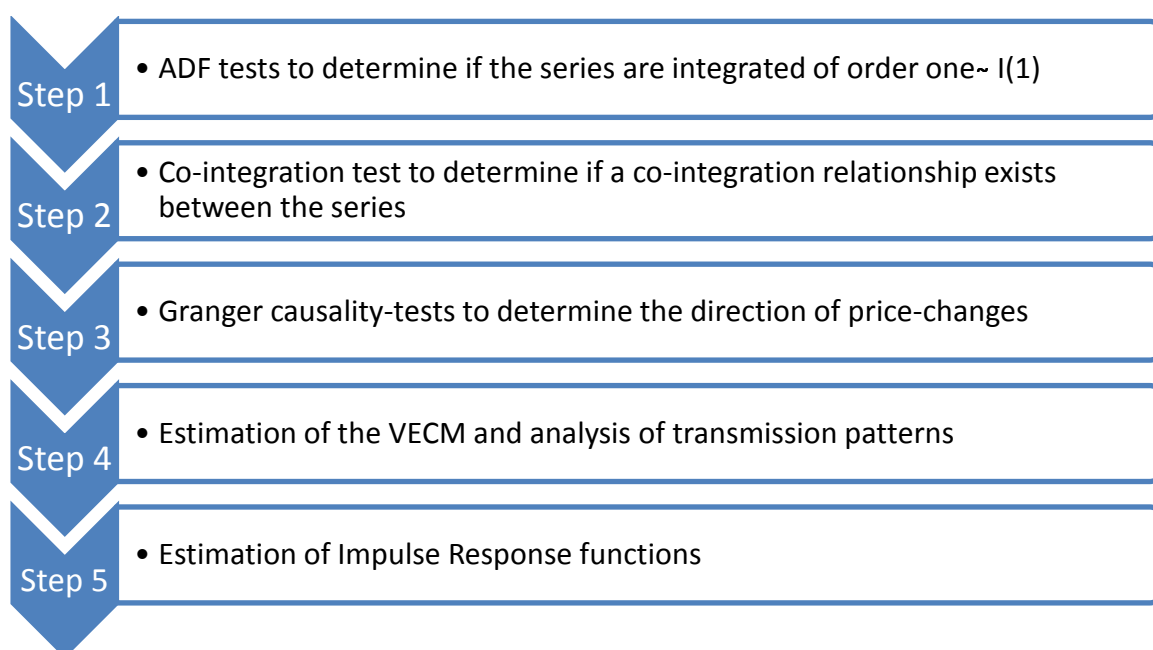
In Vector Error Correction Models, testing for Granger-causality plays an important role in order to infer which prices are explaining or influencing other prices. Sweden has only a minor role in grain export and therefore limited impact on international prices (Minot 2011). Important is, that the reference price is not affected by the Swedish market, because then no effect of the plant could be determined.

In this study the reference price in Rouen/France is used due to its high importance for the European Grain markets. A reason for that is the good connection between the major grain exporting areas in Europe as well as North and South America etc.

4.4) Econometric approach

In the following section the data is evaluated to determine patterns and properties of the time series. The approach by Engle and Granger (1987) is used for the analysis of price transmission patterns, due to its preferable properties and inference on prices. The advantage of using co-integration analysis is that short- and long-run properties are estimated. It builds up on VAR-equations in a dynamic framework, which is fitting to the available data. It incorporates the possibility of using non-stationary data what may lead to misleading results if another method is used (as described in Chapter 3). The following graph describes the different steps of the analysis:

Figure 4.3) Steps of Price transmission analysis



Source: Own drawings, inspired by Rapsomanikis et al. (2003), *Commodity Market Review 2003-2004*, <http://www.fao.org/docrep/006/y5117e/y5117e06.htm>

Chapter 5) Analysis

After the theoretical, methodical and literary background has been evaluated the focus can be set on the actual analysis of data. This chapter is divided into three parts. The first one gives an overview about the origin and modification of the data, while the second one deals with the analysis of price transmission as denoted in Figure 4.3). The third part focuses on the detection of structural breaks and to which extent an impact of the plant on prices can be determined.

5.1) The data: Origin and modification

As said before, time-series-analysis is used in this thesis. Four locations are used to evaluate the transmission patters of two qualities, feeding- and milling-wheat. That concludes that eight time series are evaluated. Six of them are the prices in different regions in Sweden. The regions are the biggest wheat producing areas, which are Mälardalen, Östgötaland-area and Skåne, as defined in Chapter 1). In the following analysis they are referred to as Norr, Öst and Skåne. The other two time series are prices for export wheat of the respective quality in Rouen, France, serving as reference price.

The history goes back until 2006. Due to the plant has been extended in late 2008 it is crucially important to analyze observations before the expected structural change occurred in order to have a good representation of the ex-ante situation. The prices are collected on a weekly basis. In total approximately 393 observations are incorporated in the analysis for each price. That is a quite good value in order to obtain good explanatory power. Due to the prices in Öst and Norr have been the same from 2006 to 2010, the time series Norr has been used in the third part, referred to as Norr/Öst. All prices are based on the spot-market prices from Lantmännen.

Because of differences in the scale of the time series, the data has been adjusted for missing values. To do that a spline-interpolation method has been used. This method is using low-order polynomials to estimate missing values according to previous and subsequent values. The advantage of this method is that it is incorporating trends in the data and therefore it is considered to give the best estimations of missing data points for this evaluation (Schumaker 1981).

For all time series, test regressions have been conducted in order to evaluate the general specification. All equations have been found to be AR(p) processes with intercept but no deterministic trend. Appendix 7.5) shows plots of the data.

5.2.) Analysis of price transmission

The price transmission part follows the steps of Figure 4.3). If not mentioned otherwise, a 5% significant level has been used.

5.2.1.) Test for the presence of unit root

The test is based on the methodology developed by Dickey and Fuller (1979), giving evidence on the data's stationarity patterns. If the time-series contain unit roots, the data is considered to be non-stationary and therefore incorporating stochastic trends. In the ADF-test, the equation is estimated:

$$\Delta p_t = \alpha_0 + \alpha_1 t + \delta_1 p_{t-1} + \sum_{i=1}^k \beta_i \Delta p_{t-i} + \varepsilon_t \quad (\text{Eq.5.1})$$

Δ is denoting first differences and α optional exogenous regressors which denote an eventual constant and trend. The lag-length k is determined by the Akaike-Information criterion (AIC). The problem with a wrong lag length is that too much or too less incorporated lags may lead to a bias and a loss of power (Akaike et al. 1998). The null hypothesis tests for a unit root versus the alternative of no unit root, which is $H_0: \delta_1 = 0$. If H_0 cannot be rejected, there is evidence for the presence of a unit root. If this is the case, the first differences must be evaluated with the same method. Rejection of the test on the first differences determines the order of integration. The data is tested with constant and no deterministic trend, as found in the test-estimations of the underlying AR(p)-processes.

Figure 5.1) Output of ADF-test

Region	Quality	Scope	Lag-length	t-value	Probability	Rejection	Order
France	Feeding	Level	3	-2.515085	0.1126	No	I(1)
		1st difference	3	-9.220087	0.0000	Yes	
	Milling	Level	3	-2.870407	0.0498	Yes	I(0)
		1st difference	2	-8.933166	0.0000	Yes	
Öst	Feeding	Level	3	-2.372256	0.1504	No	I(1)
		1st difference	2	-8.361179	0.0000	Yes	
	Milling	Level	5	-2.769696	0.0636	No	I(1)
		1st difference	1	-10.66321	0.0000	Yes	
Norr	Feeding	Level	3	-2.368035	0.1516	No	I(1)
		1st difference	2	-8.417125	0.0000	Yes	
	Milling	Level	5	-2.806797	0.0582	No	I(1)
		1st difference	0	-6.704577	0.0000	Yes	
Skåne	Feeding	Level	8	-2.328037	0.1637	No	I(1)
		1st difference	7	-6.455234	0.0000	Yes	
	Milling	Level	2	-2.511198	0.1135	No	I(1)
		1st difference	1	-10.03727	0.0000	Yes	

The ADF-test gives evidence for non-stationarity in the raw-data of the areas France (Feeding wheat only), Öst, Norr and Skåne. However, the milling-wheat quality in France is found to be stationary, $I(0)$. Due to the VECM model requires $I(1)$ variables in order to give convincing results, that may look suboptimal for the analysis. However, Banerjee et al. (1990) state that in systems with three series or more, at least two variables have to be $I(1)$. Therefore the stationary milling wheat series is not affecting the liability of the model.

After differencing one time the series' appear to be stationary, indicating that most of the data is integrated of order one, $I(1)$. The ADF-test is carried out to determine if a VECM can be validly estimated.

5.2.2) Testing for the degree of co-integration

Even though the ADF-test indicates integration of order 1, most of the series cannot be assumed to contain a co-integration relationship. Generally, integration is a necessary but not sufficient condition to conclude co-integration. In other words, the ADF-test tests time series on its stationarity properties, but further testing is needed to determine if a linear combination of the variables exists. If this is the case, series' are said to be co-integrated (Phillips and Ouliaris 1987). If the time-series contain a co-integration vector and are mostly $I(1)$, according to the Granger-representation-theorem a VEC-representation of a system exists (see Chapter 4.2).

Johansen (1991) developed a procedure to explicitly test for co-integration using a likelihood-ratio method. It gives an indication if and how many co-integration relationships exist between the variables. Proposed are two tests, the trace-test and maximum-eigenvalue-test. The advantage of the Johansen-procedure is that it gives better results in case of more than two time series, therefore other test – like the Engle-Granger-test of co-integration between two variables - are not considered. The null-hypothesis of the trace-test is defined as $H_0 = r \leq k$, with $r = 0, 1, \dots, k-1$, while the maximum-eigenvalue-test uses $H_0 = r$ vs $H_1 = r + 1$. In these cases r is the number of co-integration relationships and k the number of endogenous variables (that are the different time series).

Economic considerations lead to the assumption that both qualities follow own co-integration relationships. Therefore, the prices for the qualities are evaluated separately. To estimate cross-price-elasticities the Johansen-procedure has been conducted for all series.

Applied to the data of feeding- and milling-wheat, the general Johansen-test provides the results shown in Appendix 7.6) and 7.7), indicating that both qualities contain co-integration relationships. In the case of milling wheat maximum-eigenvalue- and trace-test show up to four co-integrating

relationships what is unreasonable because four relationships in a four equation system would indicate that a price tends to be in a long-run relationship with itself. In an n -equation system there exist maximal $n-1$ co-integration relationships (CE). Due to the model is best described by estimation with only an intercept and no trend (see also chapter 5.1.1) the trace-test gives evidence for three existing co-integration relationships. The optimal lag-length in the test has been determined by estimating unrestricted Vector Autoregression's (VAR's) and choosing the highest fit using the given criteria.

In the milling-wheat case, both tests indicate co-integration relationships to be present. However, the trace- and eigenvalue-test for feeding-wheat quality do not provide similar results. That is kind of unexpected, because the plot of the data indicates a very high degree of co-movement. Lütkepohl (2000) is comparing the power of the tests and comes to the conclusion, that the Trace test is showing higher power when there are more than two co-integrating relationships. However, he states that little is known about the performance even though both tests are commonly used in econometric application. Ultimately, he recommends using the trace-statistic if the results of both tests differ.

It is concluded that co-integration relationships exist and that there is a long-run-relationship and therefore VECM between the prices according to the Granger-representation. Following Luetkepohl (2000) three co-integration relationships are estimated.

5.2.3) Granger-causality

Granger causality can be found in the data if past values of a variable X contain information to predict future values of a variable Y . In that case, it is said that X granger-causes Y (Granger 1969). To determine the direction of causality, Granger-causality test are explicitly testing for these relationships. Direction of causality means if the France-price contains information for the Skåne-price and vice versa, causality is running in both directions of France – Skåne.

The Granger-causality procedure tests the H_0 that X does not Granger-cause Y . If the null is rejected one can conclude that X has an influence on the variable Y . All time-series are pair-wise tested that means if four time series are evaluated eight relationships are evaluated in regard to their causality patterns. In case of the commodity wheat, it is assumed that due to the relative importance of the French notation it is granger-causing the other prices. The test provides following results:

Figure 5.2) Granger causality test for feeding-wheat:

Region (column) having useful information for region (row)				
	France	Öst	Norr	Skåne
France	-	Yes	Yes	Yes
Öst	No	-	Yes	Yes
Norr	No	Yes	-	Yes
Skåne	No	Yes	Yes	-

It can be seen from the figure that France is incorporating information for all prices in Sweden. That is confirming the proposition that France serves like a reference market for Swedish farmers. Furthermore, the small country assumption is supported, that is, that Sweden does take a price follower- rather than a price setting-role. This is due to the Sweden does not have an influence on France, while the other way around causality have been found. If the French market moves, it will affect the Swedish market which is not the case vice versa. That is the case because it can be suggested that France already incorporated the information due to its price-setting role.

In addition, the regions Skåne and Öst have a quite high impact on each other indicated by highly rejected Null-hypotheses. The same counts for Norr and Skåne, while an impact of Norr on Öst is harder to reject. Overall, it can be said that farmers in all regions of Sweden are observing what happens in the other regions and adapting their prices accordingly.

Figure 5.3) Granger causality test for milling-wheat:

Region (column) having useful information for region (row)				
	France	Öst	Norr	Skåne
France	-	Yes	Yes	Yes
Öst	No	-	No	No
Norr	No	Yes	-	No
Skåne	Yes	Yes	Yes	-

Again, France shows impact on all prices what is not the case vice versa. However, it appears that the market Norr has a significant influence on Öst, even though the Norr-market is only approximately half the size. In addition, the test cannot reject the hypothesis that the price in Öst has no forecasting information on the prices in the other Swedish regions. Only the Skåne market provides useful information on the other. It appears that southern Sweden serves as reference for the other regions but not the other way around.

Furthermore, predictive information of Skåne on France can be found. That might be due to the structure and production behavior of that specific region and/or regional vicinity.

Figure 5.4) Cross-quality effects

		Feeding wheat				Milling wheat			
		France	Öst	Norr	Skåne	France	Öst	Norr	Skåne
Feeding	France					Yes	Yes	Yes	Yes
	Öst					No	No	No	Yes
	Norr					No	Yes	No	Yes
	Skåne					Yes	Yes	Yes	Yes
Milling	France	No	Yes	Yes	Yes				
	Öst	No	No	No	No				
	Norr	No	No	No	No				
	Skåne	Yes	Yes	Yes	No				

The analysis of cross-quality effects gives clarification on substitution patterns. Feeding- and milling-wheat are substitutes under certain conditions. Reasons for this can be climatic circumstances of the growing-year. Milling wheat might be of bad quality and therefore classified as feeding wheat or the feeding wheat-crop has not been satisfying so that farmers start feeding milling-wheat to their livestock.

The Granger-causality tests reveal that the French milling wheat notation contains useful information for the feeding wheat markets in Sweden. That is not the case vice versa, emphasizing the relative unimportance of Sweden for the international market. Only the Skåne price of milling wheat has an informative value for the feeding wheat market in the regions Öst and Norr.

Another conclusion can be drawn for the feeding wheat quality. It appears that feeding wheat with origin France has an informative value for milling wheat in all markets. Furthermore, Skåne has an influence on french milling wheat and all the other markets in Sweden. That is surprising, because the Skåne market for feeding wheat does not granger-cause the feeding wheat market in France, but it does for milling wheat. Logically one would suggest that for the same good causality is more likely to appear than for substitutes. However, the power of granger causality tests is quite poor and therefore the results have to be interpreted with caution.

The test is important that the results of the VECM are interpreted in the right way. If co-integration exists, causality in at least one direction must exist in the time series according to the Granger-representation theorem.

However, the power of the test can be questioned if less “clear” relationships are evaluated as in this case the impact of wheat prices on each other in the national market (Granger 1988). On the other hand, from an economic point of view the proposition that Swedish farmers take the international

price as reference price is hard to disprove. Therefore, in the latter case a leading france-price is quite likely and economic reality does not doubt the results of the test. However, as mentioned before the cross-quality causality might be such a less “clear” relationship and therefore the results have to be interpreted cautiously.

In order to smooth the results, a higher significance level has been used (20%) and only conclusions with a high degree of liability have been drawn. That is done to compensate for the poor performance that has been reported in the context of Granger-causality tests (Granger 1988). In addition, the results count for short-term behavior only. The lag has been set to two weeks that is the assumption that farmers are using only information from the other markets from the period of today until maximal two weeks ago. Allowing for longer periods – represented by a higher lag setting - all prices would influence each other and the test could not say anything about causality-patterns.

Concluding it can be said, that with some high degree of certainty France is an important reference for farmers in Sweden, due to causality exists on all Swedish markets. Furthermore, the test shows a relationship between the Swedish prices for feeding wheat and indicates price-following behavior of the regions Norr and Öst for milling wheat.

Above, the statistical properties have been proven to be fulfilled in order to estimate a VECM correctly. In the following, the long-run relationship as estimated by the model is evaluated.

5.2.4) Elasticities of feeding wheat

ADF- and Johansen-test found all necessary conditions to validly estimate a VECM. The VECM is a model for non-stationary time-series which is capturing short-run-, long-run- and adjustment-effects and shows co-integration between the variables. It serves for the actual objective to evaluate the price transmission pattern in Sweden. If the elasticities are close to one, the markets can be seen as highly/perfectly integrated. The advantage of VEC-Models is that it provides a whole picture analysis in regard to the evaluation of prices rather than a separated evaluation. However, especially price-elasticities are important for the analysis in order to determine the degree of integration in the long-run and later evaluate the impact of the plant.

Appendix 7.8) shows the estimation results of the VECM of feeding-wheat quality. The first part of the table presents the values of the long-term relationship, denoted by the different cointegration equations.

The table indicates that in the long-run the prices of France, Öst, Mälaren and Skåne are reacting quite perfectly to changes in the French wheat price.

The co-integration equation can be written as:

$$France_feeding - 1.00994 * Skåne_feeding = Error \quad (Eq.5.1)$$

That means if the French feeding-wheat price shows a positive difference of value one, the Skåne feeding wheat price will show a difference of 1.00994 SEK to the equilibrium price.

In other words: If the markets are perfectly integrated and the prices tend to be equal, the Skåne price adjusts by value one as well. The estimated value has been found to be 1.00994 SEK for every change of the French price by one SEK. It is to highlight, that in the short run the prices may differ at another rate but that the markets are co-moving in the long-run.

Different co-integration equations are estimated to model the different price changes. If the France – Skåne relationship is evaluated, the other prices Norr and Öst are held constant. To examine the relationship France – Norr, another co-integration equation is estimated with Öst and Skåne to be constant.

Johanson (2002) states that co-integration vectors can be interpreted as long-run elasticity. That would indicate that a change of 10% in the reference price leads to a change of approximately 10.994% of the price in Skåne and therefore markets are close to perfect price co-movement.

As reaction of a change in the Öst price the long-run adjustment parameter of the price in Skåne has been estimated to be 1.095 SEK per increase by one SEK, formulated by the equation:

$$Öst_feeding - 1.095 * Skåne_feeding = Error \quad (Eq. 5.2)$$

Because of the large sample, the standard errors are quite small and therefore the values given by the table are quite accurate. Therefore, no t-tests must be run to determine if the elasticities are equal to zero that is indicating perfect price transmission. It can be concluded that the elasticities are not exactly but very close to one, so that with a high degree of certainty perfect transmission can be assumed.

A very exact interpretation would be that the Skåne price tends to marginally overreact on changes in the Öst-price, that is by 0.95% (= 10% - 10.95%).

The same methodology can be applied to a change in the Norr-price, indicating that in Skåne prices change by 10.58% per 10% movement and so on. In order to obtain values for all combinations of

regions the ordering of the VECM is changed and the following table summarizes the findings for the long-run relationship:

Figure 5.5) Results for the long-run elasticities for feeding wheat

1% price movement in region (column) changes price in region (row) by:				
	France	Öst	Norr	Skåne
France	1	0.922096	0.954389	1.009941
Öst	1.084485	1	1.035021	1.095266
Norr	1.047791	0.966164	1	1.058207
Skåne	0.990157	0.913020	0.944995	1

The values are interpreted as above. The crossed out values are the ones where no clear cause – effect relationship could be found, that is a missing granger-causality.

The table gives clear results with a high degree of mutual price co-movement. However, it is to mention that Öst and Norr are reacting with a lower magnitude on the price in Skåne (9.13% and 9.45% per 10% change, respectively). That is suggesting that Norr and Öst are showing price setting behavior to a lower magnitude. Prices are adapting by 9.1%-9.5% per 10% change, because these markets have already been incorporating some of the new information that caused the Skåne-price to move.

To conclude, price changes in the different markets are transmitted between 91% and 109% to the other markets. With higher regional adjacency the price transmission happens more perfectly in some relations (France – Skåne, Öst – Norr), but less if a market leading position can be assumed (Öst – Skåne, Norr – Skåne).

5.2.5) Elasticities of milling wheat

Appendix 7.9) shows the output of the VECM for milling wheat. The analysis works exactly as in the previous case with the same equations but with changed values.

Figure 5.6) Results for the long-run elasticities for milling wheat

1% price movement in region (column) changes price in region (row) by:				
	France	Öst	Norr	Skåne
France	1	1.001229	1.012871	1.013506
Öst	0.998773	1	1.011628	1.012263
Norr	0.987293	0.988506	1	1.000627
Skåne	0.986674	0.987886	0.999373	1

The data shows that if the French milling-wheat price increases by one the Öst price is adapted by 1.001 SEK, the Norr price by 1.013 SEK and the Skåne price by 1.0135 etc. Overall the data shows a way higher degree of market integration, with all values very close to one. Therefore, perfect price transmission in the milling wheat market can be assumed.

5.2.6) Cross-quality elasticities

Figure 5.7) The cross-quality elasticities

1% price movement in region (column) changes price in region (row) by:									
Feeding					Milling				
		France	Öst	Norr	Skåne	France	Öst	Norr	Skåne
Feeding	France					1.152	1.386	1.448	1.209
	Öst					1.182	1.422	1.487	1.241
	Norr					1.150	1.384	1.446	1.207
	Skåne					1.062	1.278	1.336	1.115
Milling	France	0.868	0.846	0.870	0.942				
	Öst	0.722	0.703	0.723	0.783				
	Norr	0.691	0.673	0.692	0.749				
	Skåne	0.827	0.806	0.828	0.897				

The interpretation is the same as in the previous cases, but for cross-price-effects. For the analysis of price transmission in the feeding- and milling-wheat market the numbers are rather of minor interest. Important is, that if a shock occurred in one market they show how it transmits to the other quality. Generally, if an event in the french feeding wheat market changes the price by 10%, the milling-wheat price in Östgötaland would change by 13.9%. Overall, the milling wheat market is very responsive to changes in the feeding wheat market, while less responsive vice versa.

The cross-price elasticities are generally higher (in the direction: Feeding – Milling) or lower (in the direction: Milling – Feeding) than in the same-quality case. That is due to farmers growing only one or high share of a certain quality are not observing the market conditions for the other good as careful. Therefore, the milling-wheat markets are generally overreacting to changes in the feeding wheat market and in the feeding wheat markets changes are generally showing a lower impact on price changes in the milling wheat market.

It is interesting that milling wheat shows a higher response to feeding wheat than vice versa (because mainly elasticities > 11% per 10% change). Due to milling wheat is a higher quality, it could be assumed to be of higher importance for the people and therefore incorporating changing market information faster than the other way around. However, the data indicates that market information is incorporated faster in the feeding wheat market.

5.2.7) Implications on the speed of adjustment on feeding wheat

The second part of the output of Appendix 7.8) indicates how fast the error of the reference price is corrected. In other words, if the price of the reference changes, the adjustment term gives an indication how fast the price in the other regions react.

The equation looks for the first co-integration equation (CE1) like:

$$0.0494 * D(\ddot{O}st_{feed}) - 0.0525 * D(Norr_{feed}) - 0.0536 * D(Sk\ddot{a}ne_{feed}) = Error\ in\ France$$

(Eq.5.3)

Figure 5.8) Estimation of adjustment speed for feeding wheat

Adjustment speed of region (column) on changes from region (row)				
	France	Öst	Norr	Skåne
France	-	0.049396	0.052475	0.053593
Öst	-	-	-	-
Norr	-	-	-	-
Skåne	-	-	-	-

The results can be interpreted as follows.

If the French market shows a positive error – which is when the price increases – the Öst price adjusts by 4.94%, the Norr price by 5.24% and the Skåne price by 5.36% of the error value in the short run. That implies that the adaption to price changes happens relatively slowly. The closer to one the adjustment speed the faster is the adaption process. In the case where the price in France falls – showing a negative error - the results are vice versa.

The table shows no values for the Swedish markets. That is, because causality could not be determined between the equations and therefore the model cannot detect cause and effect of price changes and the adjustment parameters have been insignificant.

5.2.8) Implications on the speed of adjustment on milling wheat

The second part of Appendix 7.9) provides estimates for the adjustment speed in the milling wheat market. The equation is the same as Eq.5.3).

Figure 5.9.) Estimations of adjustment parameters for milling wheat

Adjustment speed of changes from region (row) in region (column)				
	France	Öst	Norr	Skåne
France	-	0.057136	0.048549	0.104324
Öst	-	-	-	-
Norr	-	-	-	-
Skåne	-	0.114116	-	-

Interpreting the results, the markets Östgötaland and Norrköping adapt slowly to the French market with 5.71% and 4.85%, respectively. Skåne however, shows a quicker reaction (10.43%). Furthermore, the region Öst has been found to react on a change in Skåne with 11.41% in the short-run. Again, empty cells indicate missing causality/insignificant values.

Therefore, inference on the adaption pattern is rather difficult and is renounced in this analysis.

5.2.9) Impulse response functions

Another way to examine the speed of adjustment is the analysis of Impulse response functions. Nevertheless, it is important to clearly identify in which market the disturbance occurred. If no granger-causality can be identified between the investigated time series, the results may be biased (Pesaran et al. 1998). Therefore, the impact of a shock occurring in France is evaluated due to its clear causality pattern.

Figure 5.10) shows the response of the markets Öst, Norr and Skåne if a shock in magnitude of the Standard deviation occurs (blue line), plus or minus one time the standard error of the equation (red lines). The Standard deviation of the estimated equations has been calculated to be 57 for French feeding wheat and 68 for french milling wheat.

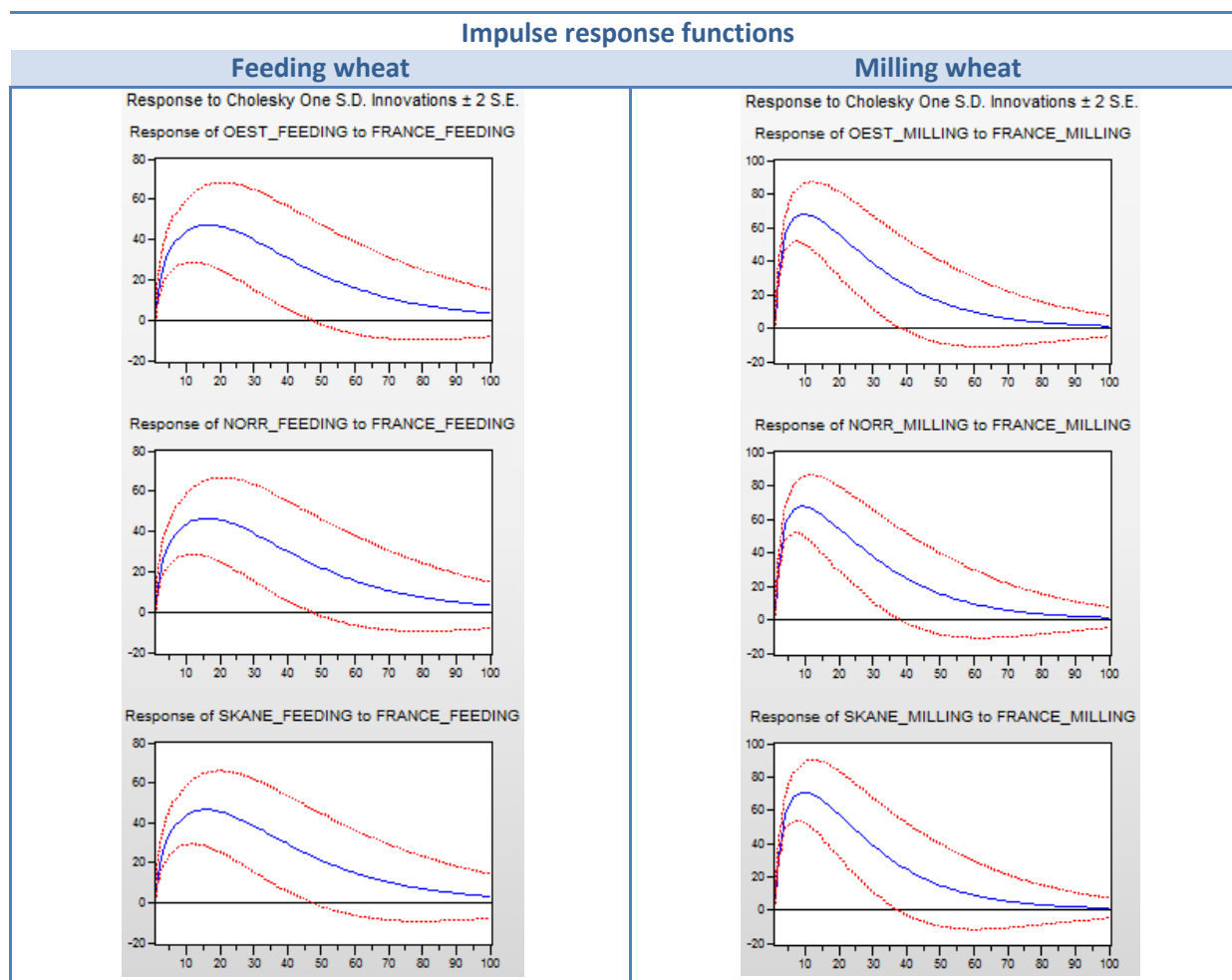
Therefore, the graphs show the effect of a price change of 57 SEK and 68 SEK respectively, that occurred in the French market and affected the price in the regions Öst (1st graph), Norr (2nd graph) and Skåne (3rd graph) for the respective quality.

However, that does not mean that the reaction of France on changes in Sweden is the same. Unfortunately, the data does not allow for further implications on the shock-transmitting properties of inner-Swedish prices.

The reaction is quite similar for all markets; however, in the case of milling wheat the reaction happens quicker due to a steeper slope of the function versus a lower slope for feeding wheat. After

approximately 15 weeks (feeding wheat) and 10 weeks (milling wheat) the shock is fully incorporated in the price before they move back to their respective long-term equilibrium.

Figure 5.10) Impulse response functions:



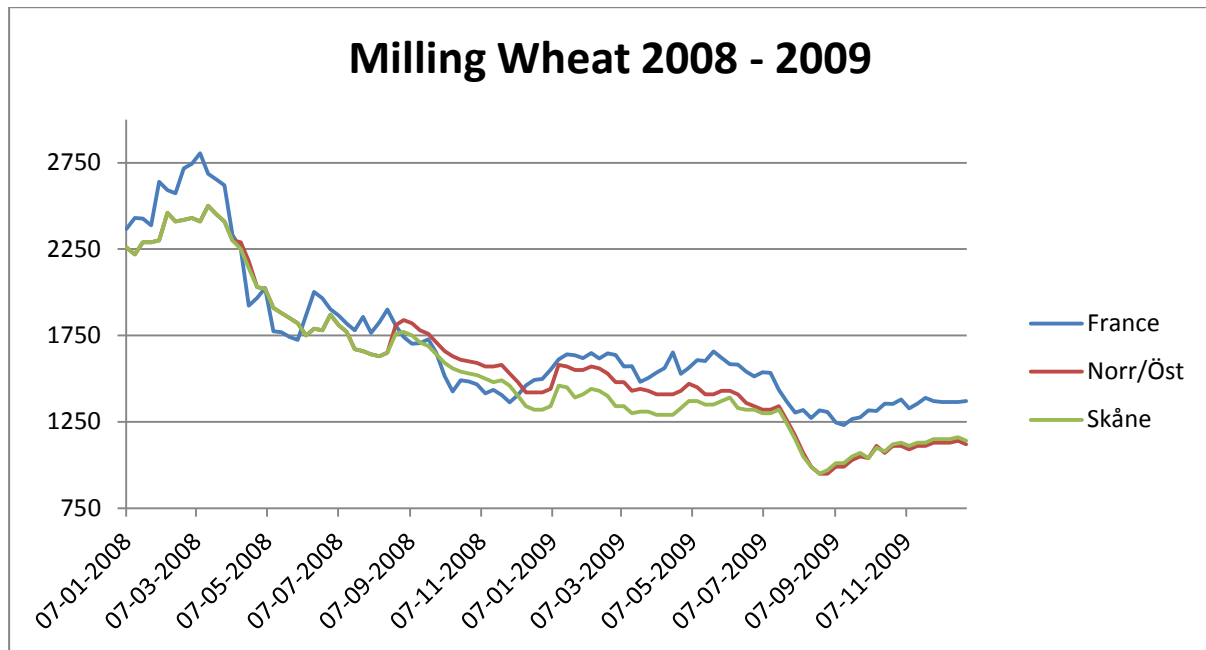
5.2.10) Summary and conclusion of the price transmission part

Using a VECM-approach the price transmission of the markets in France and Sweden has been evaluated. They indicate elasticity-values close to one for the same quality and therefore can be assumed to be integrated to a very high degree. The adjustment of new information happens between ten to fifteen weeks. The French notation showed high importance for the Swedish markets which has not been the case the other way around. Granger causality tests found some interactions within the Swedish notation; however the relationships are less clear than in the international – national context. The cross-price-elasticities have been estimated to show eventual substitution effects, but due to problematic causality relationship do not allow for further inference.

Note that in the VECM the short-term effects are included in the model but do not have a significant meaning in this context and therefore have not been evaluated.

5.3) Analysis of the price-impact

Due to the data is dependent to each other, the series itself cannot be evaluated on structural breaks. Looking at the plot of the data, the prices at the end of 2008 - when the plant-expansion was inaugurated - have decreased because of international signals, indicating that the prices after the structural change due to the plant have been falling. A plot of the whole sample differential can be found in Appendix 7.10).



Therefore, an analysis of the differential between the prices is carried out. That means:

$$Differential = Price_{France} - Price_{Sweden} \quad (Eq.5.4)$$

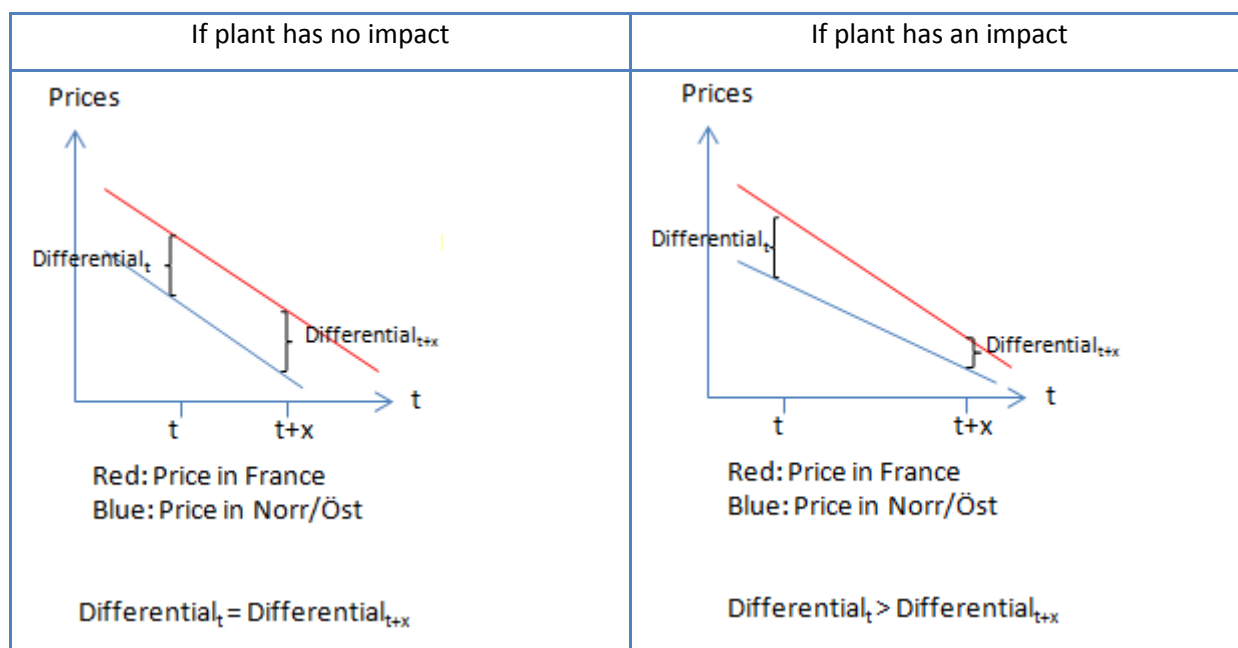
That is done by taking the difference of an independent time series (in this case France) and a dependent one (Norr/Öst and Skåne) and investigating if the relative prices have changed after the break.

Economic theory suggest the following scenario: In the end of 2008 or in the year 2009, there has been a positive shock/structural change on the Swedish grain market for milling wheat, caused by a massive increase in demand from the expanded agroethanol-plant in Norrköping. Due to international signals however, the absolute prices decreased both nationally and internationally in the period November/December 2008 – June/July 2010. Therefore, the distance between prices has to be examined, to determine if the Swedish price got relatively more expensive versus the French price. It is assumed that the massive increase in demand is causing the Swedish price to increase in

comparison to the French price, even though absolute prices have been decreasing in the period of interest.

The situation can be visualized by the following figure. The France price is generally higher due to higher transaction costs. The co-integration relationship as “force” between the prices makes sure that in the normal case the prices move parallelly:

Figure 5.11) Differential analysis



The reasoning behind the evaluation of the differential is that it is showing how the prices behave relative to each other. If the regional market falls slower than the international market, the difference between the prices changes and the differential becomes smaller due to the regional shock is compensating some of the negative movement from the absolute price decrease in France. The decrease in prices is denoted by the red and blue line with a negative slope. If there was no impact on the Swedish market, the prices should fall proportionally - due to perfect price transmission - and the differential remains the same at the beginning and the end of the period of interest. On the other hand, if there was an increase in Swedish prices due to the plant, the prices become relatively more expansive, resulting in a smaller differential at $t+x$, which is denoting the time at the end of the break.

Note that this could be done by division of the prices as well, that is:

$$Relative\ Price = P_{Sweden} / P_{France} \quad (Eq.5.5)$$

Then, if the Swedish price increases relative to the French price, the fraction would become bigger in the period of interest. However, due to an easier analysis of the differential in the way of Eq.5.4, the way of analysis as in Eq.5.5 is not pursued.

5.3.1) Gregory Hansen test on breaks in the co-integrating vector

To determine if the co-integration vector shows a structural break, the procedure by Hansen (1992) and Gregory et al. (1996) has been used. The test uses variables that are co-integrated and therefore dependent on each other, in order to determine if and at which date the co-integration vector changed (Gregory et al. 1996).

The idea behind the test is that an independent variable is not affected by a shock in a specific region (that is France), while the dependent variable is affected (in this case Norr/Öst). By testing the co-integration vector on structural changes, it can be analyzed if the long-run relationship has been affected by a specific event.

In this case, the CE can be interpreted as behavior of market participants. As shown above, the behavior is constantly the same over the whole sample. The markets in Sweden react perfectly to changes in France and therefore the market participants are assumed to always adapt the same way (by approximately 10% per 10% change, see chapter 5.2). If the Gregory Hansen test finds a break in the co-integration vector, that would indicate a change in behavior due to new market information, causing the long-run behavior to change.¹⁹

As determined before, there is no causality between the Norr/Öst prices on the French price. Therefore, the French price has the necessary properties to serve as independent variable and is assumed not to be affected by a possible shock in Sweden, because French market participants are not incorporating information of the Swedish market for their calculus. However, causality could not be rejected for the Skåne price, which might lead to difficulties.²⁰ Nevertheless, the analysis is carried out for all three regions. That implies the assumption that the demand shock caused by the plant-expansion had had no impact on the international markets.

The test considers level shifts, level shifts with trends and regime shifts. The change in level is the most likely case in this analysis. The one time shock affects the long-term relationship one time and

¹⁹ Nevertheless, an evaluation of the CE does not make sense, because this analysis is interested in determining an absolute effect of the plant and not an effect on the calculus of market participants.

²⁰ If the shock is transmitted from Norr/Öst to Skåne, which is the case due to price transmission, France would incorporate the information due to the break passively. It is necessary to assume that this is not the case and therefore the results of the differential France – Skåne has to be carefully interpreted.

remains at a certain level after the break and there is no reason to assume that the behavior is constantly reconsidered throughout time (indicated by a time-dependent variable).

Figure 5.12) Results of the Gregory Hansen test for milling wheat

Time series:	Break dates (Month/Day/Year)
	[t-statistics]
Milling wheat	
France – Norr/Öst	6/22/2009 [-3.018185]
France – Skåne	9/07/2009 [-4.113940]
Feeding wheat	
France – Norr/Öst	10/15/2007 [-3.808788]
France – Skåne	10/15/2007 [-3.812334]

The test for milling wheat finds a break in level in June 2009 and September 2009 respectively. It appears that after the inauguration of the expanded plant the demand increased step by step what is changing the long-term relationship in June/July 2009. Due to the high degree of integration the increase in demand is measureable in Skåne as well, however incorporating a delay of 10 to 12 weeks. That is a viable result given the gradual increase in input (Figure 1.3).

The same test for feeding wheat indicates a change in co-integration vector in October 2007. The reason is unknown and due to the date is outside the period of interest there is no connection to the plant.

This test indicates that in the case of milling wheat the market participants actively changed their behavior to a new long-run relationship between the prices, indicating a durable effect of the plant. In the case for feeding-wheat, however, this observation cannot be made. That is presumably due to an unclear link between the qualities, the plant is mainly consuming milling wheat for production. The market participants for milling quality are incorporating the information in regard to the supply-demand conditions, while in the feeding-wheat market other information is taken into account to determine the long-run relationship. However, due to substitution patterns the shock is still assumed to transmit to the other market.²¹

²¹ Even though the cross-price-elasticities are missing causality and no statistical proof can determine the substitution patterns in this analysis, economic practice suggest the assumption that the break still transmits to the other quality

5.3.2) Analysis of the differential

To analyze the magnitude of shocks, the behavior of the differential must be evaluated. Estimating a new VECM for the ex-ante and ex-post situation is no viable alternative because it estimates the elasticities and does not allow for computing an absolute effect of the plant. The Gregory-Hansen procedure indicates a change in the long-run relationship in 2009 giving an indication of when the break occurred in the differential.

To conduct the differential-analysis, a series with observations between the years 2006 to 2010 is evaluated on structural breaks. Because the prices to May 2010 have been the same, the Norr prices are taken as joint series for Östgötaland and Norrköping. The shortening of the sample is necessary to get more precise break dates. A multiple structural break test gives the following results:

Figure 5.13) Estimated break dates in the differential

Time series		Break dates (Month/Day/Year)			
		Milling wheat			
France – Norr/Öst	4/09/2007	3/17/2008	12/08/2008	8/10/2009	5/03/2010
France – Skåne	5/28/2007	3/17/2008	12/15/2008	8/17/2009	5/03/2010
		Feeding wheat			
France – Norr/Öst	03/12/2007	12/03/2007	8/11/2008	6/08/2009	4/26/2010
France - Skåne	03/12/2007	12/03/2007	8/11/2008	8/31/2009	5/03/2010

For milling wheat, both differentials show breaks more or less at the same dates. In the first and third structural break Skåne has been two and one week behind the shock dates for Norr and Öst. The test finds a break in August 2009, close to the date that has been found in the Gregory-Hansen procedure. As seen in Figure 1.3) the yearly demand of the plant increases gradually. The stepwise increase in demand is an explanation why the price-effect occurred not suddenly after inauguration in November 2008, but later in 2009.

For feeding wheat, the dates of the first three breaks are the same while the fourth and fifth break is not the same but close to each other. In August 2009 the differential changed in Skåne two weeks after the milling wheat market, Norr and Öst changed already in June. That can be seen as reaction on the break in the milling wheat market; however, the reasons are less clear due to the plant is not directly affecting the feeding quality.

Partitioning the sample into subsamples for each break and estimating by OLS, allows for inference on the properties of the data. For this analysis, the subsample between the fourth and fifth break is of special interest, showing the impact of the plant in the following nine months after full capacity

was presumably achieved in August 2009.²² The following Figure gives the output of the estimation of the subsample August 2009 – May 2010:

Figure 5.14) Change in differential France – Norr milling wheat

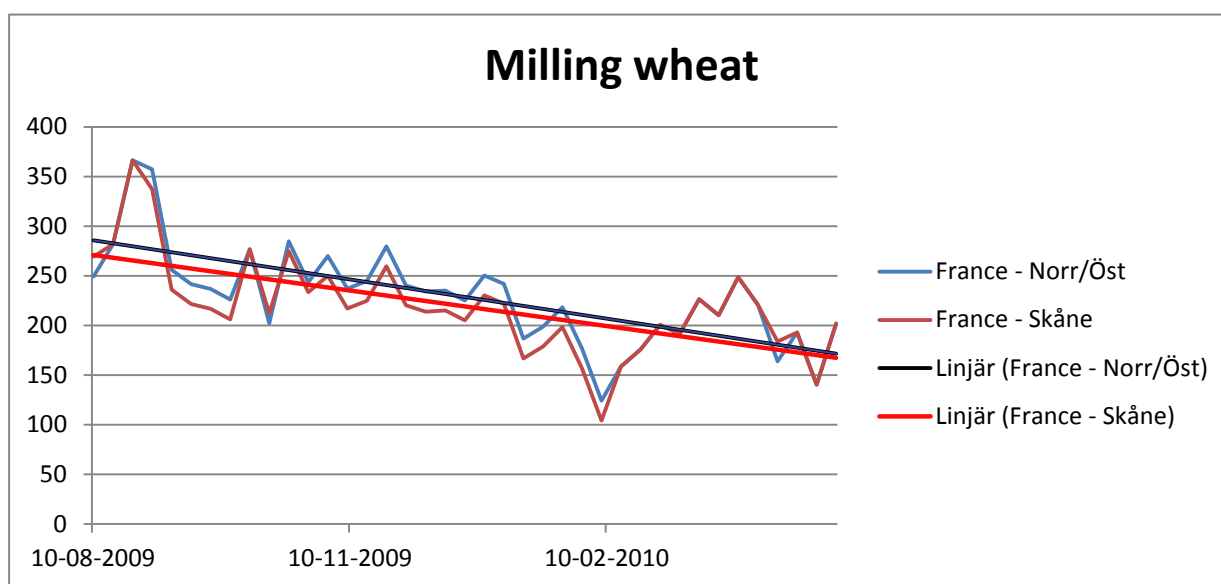
Sample: 8/10/2009 5/03/2010				Included observations: 39
Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	735.7487	90.44951	8.134358	0.0000
TREND	-2.746481	0.488014	-5.627874	0.0000

Figure 5.15) Change in differential France – Skåne milling wheat

Sample: 8/17/2009 5/03/2010				Included observations: 38
Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	723.4693	106.1671	6.814437	0.0000
TREND	-2.725725	0.571332	-4.770823	0.0000

Despite few observations and high standard errors both coefficients are significant. Regressing the data on a constant and a trend, it is possible to see how the differential changed over the time period of nine months:

Figure 5.16) The differential between the break dates regressed on constant and trend



The figure reveals that the differential decreased by 2.74 SEK per week (that is the trend variable, Figure 5.14), over a period of 39 weeks (that are the observations). That is the time between the first and the second break. Using these numbers to calculate an absolute effect, leads to:

$$\text{Absolute Effect} = \text{Time between breaks} * \text{Trend of the differential} \quad (\text{Eq.5.6})$$

²² It is assumed that the breaks has been caused by the plant and not by any other event

That is indicating a price change by up to 106.86 SEK/ton due to the plant.

The effect on the Skåne milling-wheat market is nearly the same as above due to a high degree of market integration. Per week, the differential decreased by 2.72 SEK indicating that over 38 weeks the price changed up to 103.36 SEK/ton.

Figure 5.17) Change in differential France – Norr feeding wheat

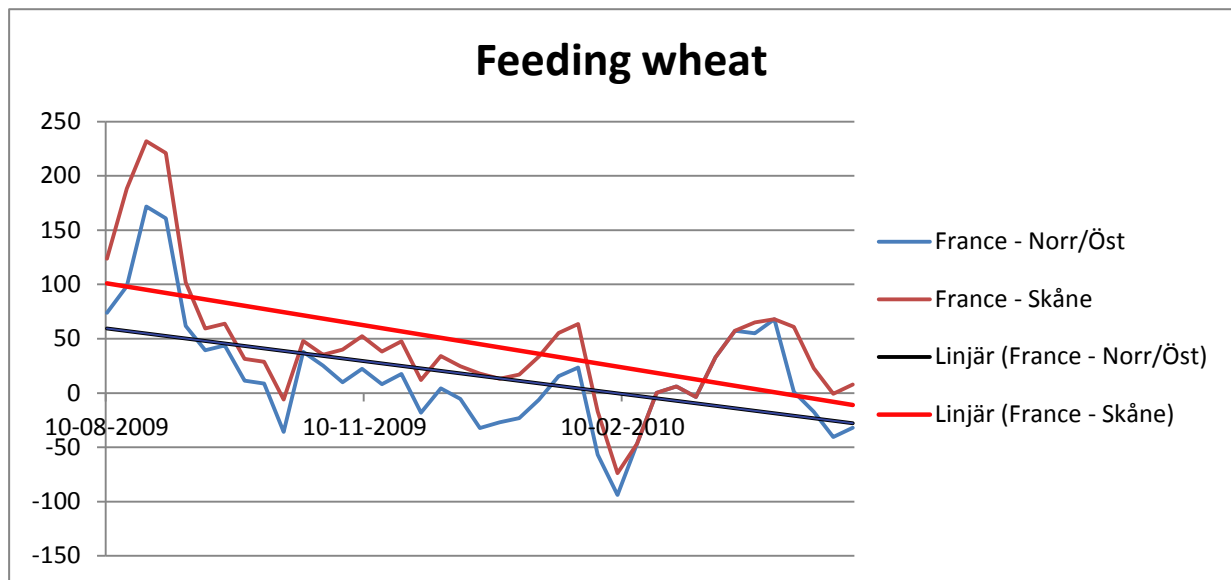
Sample: 8/10/2009 5/03/2010				Included observations: 39
Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	347.3836	119.1323	2.915949	0.0060
TREND	-1.807032	0.642770	-2.811320	0.0078

Figure 5.18) Change in differential France – Skåne feeding wheat

Sample: 8/17/2009 5/03/2010				Included observations: 38
Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	571.7920	143.8728	3.974289	0.0003
TREND	-2.850760	0.774243	-3.681997	0.0008

The plot of the data with included regression is:

Figure 5.19) The differential between the break dates regressed on constant and trend



The effect on the feeding wheat market is lower for the Norr area but a little higher for Skåne, indicating a price change of 70.2 SEK/ton and 108.3 SEK/ton, respectively. The outputs give evidence that the Skåne feeding wheat market slightly overestimates price movements from the Norrköping milling wheat market. Due to the shocks are very close to each other with approximately the same magnitude, some cross-quality transmission patterns have to be assumed. However, the cross-price

elasticities are facing the problem of non-causality and therefore no substitution patterns could be clearly identified. Therefore, the results for feeding wheat have to be interpreted cautiously.

Summarized, the total effects are:²³

Figure 5.20) Total price changes due to the plant

Total Effect		
Milling wheat	France – Norr/Öst	$39 \times 2.75 = \mathbf{107.25}$ SEK/ton
	France – Skåne	$38 \times 2.73 = \mathbf{106.47}$ SEK/ton
Feeding wheat	France – Norr/Öst	$39 \times 1.81 = \mathbf{70.59}$ SEK/ton
	France – Skåne	$38 \times 2.85 = \mathbf{108.3}$ SEK/ton

5.4.) Problems in the analysis

Analyzing the properties of the residuals and common problems in econometric modeling, the analysis shows some disadvantages. The estimations are facing the problems of autocorrelation, heteroscedasticity and non-normality of the residuals. That leads to wrong standard errors; however, the parameter-estimators are unbiased and consistent and therefore correctly estimated.

Addressing the problem of autocorrelation Brueggeman et al. (2006) claim that there is no remedy to solve this issue in VECM. In regard to heteroscedasticity a Generalized method of moments (GMM)-model could be used and consecutive Vector Autorregressions estimated with robust standard errors (HAC). However, the problem of autocorrelation remains and as a result normality of the residuals cannot be achieved with both approaches.

That means that all tests have to be interpreted cautiously, even though the relatively large sample size is compensating for these issues to some extent.

Another problem has already been mentioned in the Chapters 2.1) and 3.2.3). That is, that if transport- and transaction costs are vulnerable to trending behavior, a co-integration relationship between prices does not necessarily emphasize good arbitrage conditions. That means, that the result of perfect price transmission would either be caused by other reasons than by the LOP/Arbitrage or the results would not be significant. However, transport-cost have not been evaluated in this thesis, therefore a clear answer in regard to significance of the VECM cannot be given.

²³ It would be possible to compute the price changes with the elasticities as given in Figure 5.5) – 5.7). Knowing that the impact has been 107.25 SEK/ton, multiplying with the elasticities leads to the respective changes in the other regions. However, causality could not be determined so that this is not an option in this case.

5.5) Remarks

Some remarks have to be considered in regard to the analysis. After May 2010 other shocks have been found in the data, making further tracing of the expansion impossible. It is generally possible that the shock caused by the plant affected the prices in the future. However, a separation of the plant impact is econometrically impossible.

Furthermore, the results for the feeding wheat market must be interpreted cautiously due to the fact that a structural break has been found in the data before the market of milling wheat has been affected. That is surprising, because the feeding wheat market is not directly concerned by an increase in demand for milling wheat and substitution/cross-quality transmission patterns could not be statistically determined. However, the shock appears approximately at the same time for both qualities, from August 2009 to May 2010. Implications are that either the shock in the feeding-wheat market has been caused by a different event or that the granger-causality tests are wrong for the cross-price elasticities. The first would rather be unlikely due to the same break point, length of the shock and very similar magnitude, while the latter would not be surprising because of the poor power that have been reported for granger-causality tests.

At last, it is important to assume that the break in August 2009 has really been caused by the plant. Of course there is the possibility that the event underlying this break has had another reason, for example quality differences of the overall crop or another structural change somewhere in Sweden. However, a clear identification of a specific reason is impossible and the hypothesis that the shock has been caused by the plant is quite likely. Research on alternative events that may have been causing the break in 2009 gave no results.

Overall, the results are pointing in the same direction. The analysis of the differential results in nearly the same price changes for all markets and qualities and emphasizing the results from the market integration-part despite the presence of the here named statistical problems.

Chapter 6) Conclusion

In this thesis the degree of price transmission and effect of a structural change in the Swedish wheat market has been evaluated. A Vector error correction model approach has been used to determine the integration of the markets while differential analysis gives clarification on the effect the expansion of the ethanol-plant in Norrköping had had on the prices.

The data is integrated of order one and granger-causality exists at least in one direction, so that a VECM can be validly estimated. The reference price has found to fulfill the statistical properties in order to analyze the differential.

The markets have been found to be highly integrated. That integration is a little lower in the feeding-wheat than in the milling wheat market. However, the elasticities were 0.913 – 1.095 for feeding- and 0.988 – 1.014 for milling wheat. That is very close to one and therefore nearly perfect price transmission for feeding wheat and perfect price transmission for milling wheat can be assumed. The analysis of the short term effects indicated a slow adaption to the equilibrium, provided significant values. IR-functions revealed that shocks in the French feeding wheat market cause an adaption-process that is taking approximately twelve to fifteen weeks to be incorporated in the Swedish market.

To see if the expansion of the plant in Norrköping had an effect on the relative prices, the differential has been evaluated. The Gregory-Hansen test reveals a break in the co-integration-relationship in June 2009 in Norr/Öst and September 2009 in Skåne for milling wheat, which can be interpreted as a change in price-setting behavior that occurred approximately six to nine months after inauguration with a delay. For the feeding wheat market the Gregory-Hansen test found a break in 2007 and therefore has no meaning for this analysis.

Structural break tests reveal breaks in the differential in August 2009 and May 2010. Assuming that the breaks have been caused by the plant, regression analysis allows for inference on the magnitude. According to that, the prices changed by 106 – 107 SEK/ton for milling wheat and 70 – 108 SEK/ton for feeding wheat.

Concludingly, the expansion of the plant had an impact on prices under the assumption that the breaks has been caused by the plant. Due to price transmission the structural changes are transmitted to the feeding wheat market, even though it is not directly affected by an increase in demand. However, the results have to be interpreted cautiously due to typical problems in econometric modeling.

Going back to the problem formulations of Chapter 1.2), two questions were imposed:

- 1) How do price-changes transmit to other markets and to what extent do they react to structural changes that occur in one region?
- 2) How have prices been influenced in the three areas Mälardalen, Götaland and Skåne by the plant?

These two questions have been answered:

- 1) Prices show nearly perfect co-movement but with unknown substitutions patterns. The markets can therefore be considered to be highly integrated
- 2) Under assumptions, the prices in the different regions have been influenced by 70 SEK – 108 SEK. Therefore, it can be said that the plant affected the prices, given that the underlying assumptions are fulfilled.

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Appendix

Appendix 7.1) Definitions of the LOP

There are several other definitions of law of one price. One is that the spatial arbitrage condition holds as equality and addresses the presumption of continuity of trade. According to this “strong” version of the LOP, there is no trade at all if the price plus transportation cost in an exporting country is higher than the price in an importing country. Another definition is the purchasing power parity (PPP) that is an aggregate version of the LOP (Fackler and Goodwin 2001). It states that every commodity has one price adjusted by price indices, so that with one unit of a certain currency it should be able to purchase exactly the same amount of goods in a different market (Taylor and Taylor 2004).

The definitions – “weak” LOP, “strong” LOP and PPP- may sound the same. However, the assumptions behind them are different and more or less restrictive. Because the LOP is only the basic foundation of spatial price analysis the theory and its advantages and disadvantages are not explained in detail. Important is the understanding of the basic idea behind the analysis of spatial price integration. Further basic knowledge with examples can be obtained from Mankiw (2012). Empirical studies about the validity and restrictions of the concept is given by Richardson (1978) and Haskel and Wolf (2002).

Takayama and Judge (1971) write, that for a set of markets and under the typical assumptions of the shape of production- and utility-function, a competitive equilibrium exists that will be pareto efficient. This will also hold in a set of competitive, regional markets that trade with each other at fixed transport costs. A property of this equilibrium is that if trade occurs between any two regions, the import-price is equal to the export-price plus the unit transport cost. Is this the case the market can be considered spatially integrated (Ravallion 1986).

Appendix 7.2) The Theory of Impulse Response Functions

Impulse responses reflecting the exogenous shock effects to prices of n-markets may be given for a set of n-prices by:

$$P_t = \sum_{k=0}^{\infty} M_k e_t - k. \quad (\text{Eq.7.1})$$

The price P_t is expressed as a function of current and lagged impulses or shocks. An impulse response function represents the adjustment process and traces the impacts of shocks over time. M_k is an $i \times j$ – matrix and there exists k such matrices, depending on the number of lags that are used. The index

"i" stands for the respective price and "j" for the j-th shock. These impulse response functions describe the impact of certain shocks j on the price i , and the matrix M allows for different responses in different markets. Due to the system can be extended by any number of prices, there exist n^2 response functions. Taking for example three time series ($n=3$), let's say inflation (Inf), money supply (M2) and interest rate (r), then there are $3^2=9$ impulse response functions (thereafter IRF) that capture the effects of each time-series on itself and the other variables (Inf on Inf, Inf on M2, Inf on r , M2 on Inf, M2 on M2 and so on...). The advantage of these IRF's is that they allow richer inference on the dynamics of shock adjustment, while most other techniques often just test whether co- and market-integration is statistically present. Often scientists combine the two methods to find co-integration and then to evaluate the range of shocks, because IRF's can be seen more like a tool for further evaluation. Most of the theories on Impulse Response Functions use similar models but the idea behind is the same. Potter (1995) indicates different treatment in the statistical foundation of linear and non-linear IRF. A linear time series is not accounting for structural and behavioral changes and therefore it may be crucial to use the right method in order to obtain credible results (Potter 1999).

Appendix 7.3) The theory behind VECM's

Consider two regressions, that are co-integrated of order one ($I(1)$) and their linear combination is stationary. That linear combination may be written as:

$$Y_t = \beta_1 + \beta_2 X_t + u_t \quad (\text{Eq. 7.2})$$

If Eq.7.2) is stationary, the error u_t can be expressed by the formula:

$$u_t = Y_t - (\beta_1 + \beta_2 X_t) \quad (\text{Eq. 7.3})$$

The term in brackets is called equilibrium-relationship because both variables X and Y cannot move to far apart from each other in the long-run, otherwise u_t would not be stationary anymore. Therefore, u_t can be called the equilibrium error.

Using the information and definitions from Eq. 7.2) and Eq. 7.3) another model can be defined, the ECM:

$$\Delta Y_t = \alpha_0 + \alpha_1 \Delta X_t + \alpha_2 u_{t-1} + \varepsilon_t \quad (\text{Eq. 7.4})$$

Where u_{t-1} is the previous period equilibrium error. If $u_{t-1} = 0$, Eq. 7.4 has been in equilibrium in the previous period. However, if $u_{t-1} \neq 0$ the model has not been in equilibrium in the previous period. The estimated parameter α_2 corrects this disequilibrium.

Typically α_2 is smaller while u_{t-1} is bigger than zero. Then, the term $\alpha_2 u_{t-1}$ in the model is smaller than zero and ΔY_t becomes smaller as well. That means, that Y_t moves closer to its long-term equilibrium with X (Gujarati 2008).

Appendix 7.4) Markov – switching regime models

Defining the three different equations, which are

- | | |
|--------------------------------|------------|
| 1) $P_{2t} - P_{1t} < r_{12t}$ | (Regime 1) |
| 2) $P_{2t} - P_{1t} > r_{12t}$ | (Regime 2) |
| 3) $P_{2t} - P_{1t} = r_{12t}$ | (Regime 3) |

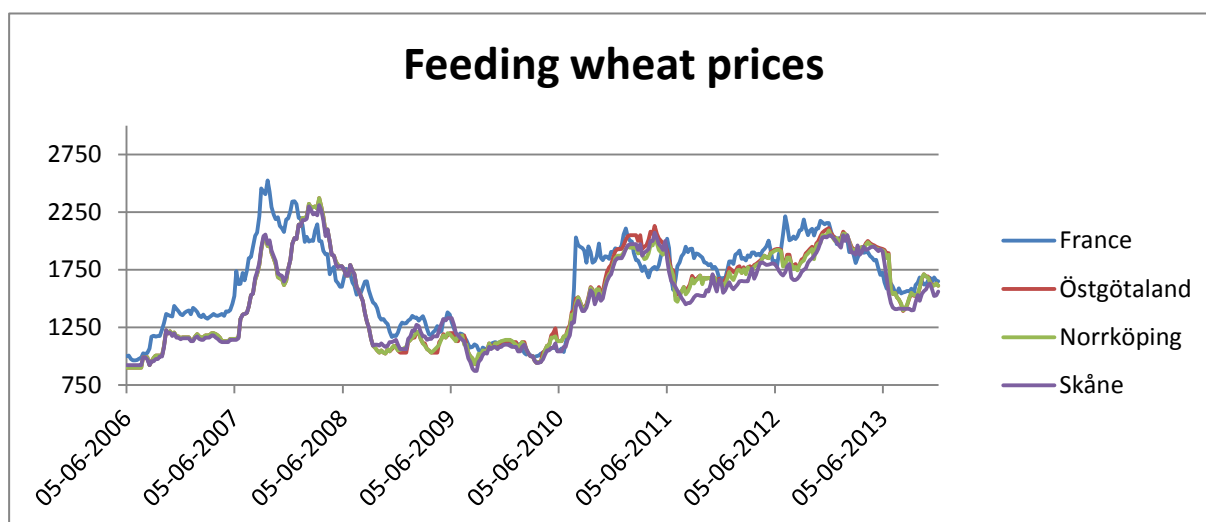
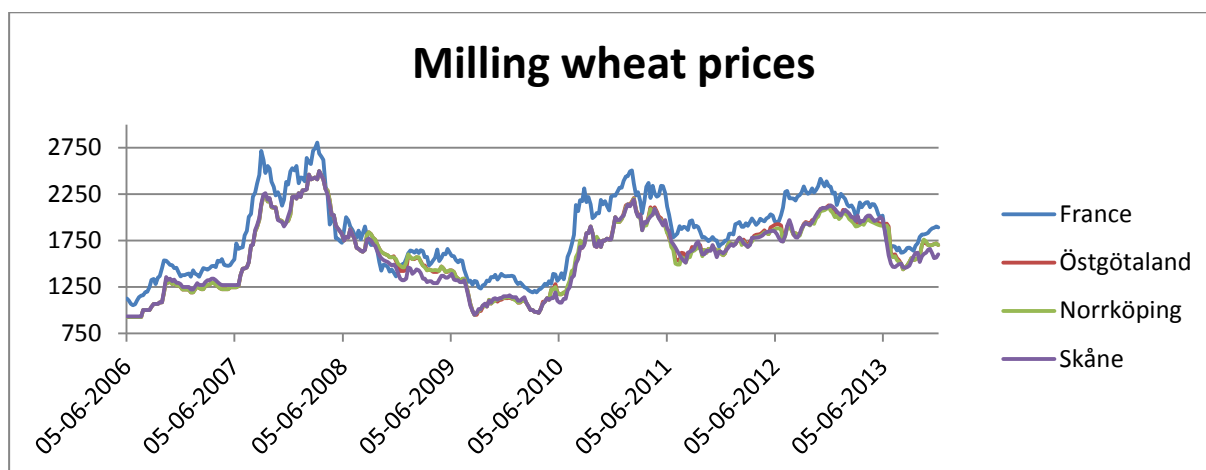
This approach tests the Null hypothesis of the different regimes. There exists a probability function:

$$f(s_t | \theta) = \lambda_1 f_1(s_t | \theta_1) + \lambda_2 f_2(s_t | \theta_2) + (1 - \lambda_1 - \lambda_2) f_3(s_t | \theta_3)$$

Where s_t = spread between the prices, θ_i = parameters defining the regimes probability distribution of the regimes and λ_i = the probabilities of being situated in regime 1 or 2. By estimating the function, probabilities are found that gives evidence how the evaluated locations can be classified in regard to their trading patterns (Fackler and Goodwin 2001).

Nevertheless, the model is dependent on its parameters and may require extensive modification for fitting the data to the procedure. If it is expected that regime-switching properties are present in a data-set, it is useful to apply this method despite eventually occurring identification problems. Otherwise, Jochmann and Koop (2011) proposed a method that is integrating different trade patterns in the Vector-Error-Correction model in the framework of the co-integration approach by Engle and Granger (1987).

Appendix 7.5) Plot of the data



Appendix 7.6) Results of the Johansen test for feeding wheat

Included observations: 390

Series: FRANCE_FEEDING OEST_FEEDING NORR_FEEDING SKANE_FEEDING

Lags interval: 1 to 2

Selected (0.05 level*) Number of Cointegrating Relations by Model

Data Trend:	None	None	Linear	Linear	Quadratic
Test Type	No Intercept	Intercept	Intercept	Intercept	Intercept
	No Trend	No Trend	No Trend	Trend	Trend
Trace	3	3	4	2	4
Max-Eig	0	0	0	0	0

Appendix 7.7) Results of the Johansen test for milling wheat

Included observations: 389

Series: FRANCE_MILLING OEST_MILLING NORR_MILLING SKANE_MILLING

Lags interval: 1 to 3

Selected (0.05 level*) Number of Cointegrating Relations by Model

Data Trend:	None	None	Linear	Linear	Quadratic
Test Type	No Intercept	Intercept	Intercept	Intercept	Intercept
	No Trend	No Trend	No Trend	Trend	Trend
Trace	3	3	4	2	4
Max-Eig	3	2	4	2	2

Appendix 7.8) VEC Output for feeding wheat

Sample (adjusted): 6/25/2006 12/08/2013

Included observations: 390 after adjustments

Standard errors in () & t-statistics in []

Cointegrating Eq:		CointEq1	CointEq2	CointEq3
FRANCE_FEEDING(-1)		1.000000	0.000000	0.000000
OEST_FEEDING(-1)		0.000000	1.000000	0.000000
NORR_FEEDING(-1)		0.000000	0.000000	1.000000
SKANE_FEEDING(-1)		-1.009941	-1.095266	-1.058207
		(0.10195)	(0.03416)	(0.03156)
		[-9.90638]	[-32.0626]	[-33.5344]
C		-105.2522	109.6889	65.47719
		(156.919)	(52.5793)	(48.5708)
		[-0.67074]	[2.08616]	[1.34808]
Error Correction:	D(FRANCE_FEEDING)	D(OEST_FEEDING)	D(NORR_FEEDING)	D(SKANE_FEEDING)
CointEq1	-0.017217	0.049396	0.052475	0.053593
	(0.01839)	(0.01410)	(0.01383)	(0.01382)
	[-0.93606]	[3.50341]	[3.79311]	[3.87923]
CointEq2	0.158369	-0.027487	0.104270	0.037250
	(0.12759)	(0.09781)	(0.09597)	(0.09584)
	[1.24120]	[-0.28103]	[1.08650]	[0.38868]
CointEq3	-0.032395	-0.040988	-0.189001	0.011528
	(0.13509)	(0.10356)	(0.10161)	(0.10147)
	[-0.23980]	[-0.39580]	[-1.86008]	[0.11360]

Appendix 7.9) VEC Output for milling wheat:

Sample (adjusted): 7/02/2006 12/08/2013

Included observations: 389 after adjustments

Standard errors in () & t-statistics in []

Cointegrating Eq:		CointEq1	CointEq2	CointEq3
FRANCE_MILLING(-1)		1.000000	0.000000	0.000000
OEST_MILLING(-1)		0.000000	1.000000	0.000000
NORR_MILLING(-1)		0.000000	0.000000	1.000000
SKANE_MILLING(-1)		-1.013506	-1.012263	-1.000627
		(0.04812)	(0.02585)	(0.03014)
		[-21.0640]	[-39.1525]	[-33.1969]
C		-186.7056	3.647621	-10.44836
		(79.6924)	(42.8218)	(49.9237)
		[-2.34283]	[0.08518]	[-0.20929]
Error Correction:	D(FRANCE_MILLING)	D(OEST_MILLING)	D(NORR_MILLING)	D(SKANE_MILLING)
CointEq1	-0.025353	0.057136	0.048549	0.104324
	(0.03809)	(0.02214)	(0.02230)	(0.02132)
	[-0.66561]	[2.58016]	[2.17668]	[4.89240]
CointEq2	-0.050198	-0.333246	-0.077551	-0.111772
	(0.27688)	(0.16097)	(0.16213)	(0.15500)
	[-0.18129]	[-2.07025]	[-0.47833]	[-0.72110]
CointEq3	0.109705	0.165205	-0.064363	0.092647
	(0.25564)	(0.14862)	(0.14969)	(0.14311)
	[0.42914]	[1.11161]	[-0.42998]	[0.64738]

Appendix 7.10) Price differential France – region

